The Motor

Electrical MANUAL

MOTOR CAR ELECTRICAL
EQUIPMENT SIMPLY
EXPLAINED

FULLY ILLUSTRATED

EIGHTH EDITION

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THE MOTOR ELECTRICAL MANUAL

THE MOTOR ELECTRICAL MANUAL

THE most practical guide to the electrical equipment of the modern car. A fully illustrated handbook on the working principles, maintenance and repair of lighting, ignition and starting systems and auxiliaries.

EIGHTH EDITION

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PREFACE

IT is no exaggeration to state that without the aid of electricity motoring as we know it to-day would be impossible. Ignition, lighting, starters, screen wipers comprise some of the essentials, and there must be included items such as traffic indicators, stoplights, de-frosters, radio and other auxiliaries.

The purpose of this manual is to explain the working principles of all this equipment and to give practical information on its maintenance and repair.

This edition, the eighth in its series, has been rewritten and rearranged, with the inclusion of numerous additional illustrations.

Replacements requiring more than average skill are regarded as work for the service station, but all adjustments and repairs within the scope of the amateur of average skill are dealt with in these pages in simple and non-technical language.

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CHAPTER I.

Principles of Electricity.

WITHOUT electricity modern motoring would be impossible. Now a statement like that needs some little amplification—many people would regard it as unjustifiable altogether. They might point out that oil and acetylene gas are still capable of producing quite a good lighting effect for reasonable speeds! And as for the not unimportant item of ignition, was not the blow-lamp once considered sufficient for the job?

But we are now dealing with the part played by electricity in motoring to-day. Ignoring the question of compression ignition, which is confined mainly to commercial vehicles, it is a little difficult to imagine a modern car sans plugs, coil or magneto, dynamo, battery, self-starter, lights from head to tail, Trafficators, horn and screen wiper. Quite a comprehensive little list so far, but add a few more items—defrosters, petrol pumps, lifts and gauges, cigarette lighters, magnetic speedometers, air conditioners and radio. Then we begin to appreciate electricity's tasks in road travel.

The object of this manual, however, is not merely to catalogue the various electrical gadgets to be found on your car. We want, first of all, to offer an explanation in simple terms of the working principles of electrical equipment. Then will follow descriptions of the instruments and apparatus in common use, together with hints and instructions on their maintenance and repair. There can be no doubt that a proper understanding of working principles is the first step to correct diagnosis of electrical faults and the best methods of overcoming such troubles. It should be borne in mind

that repairs to the electrical equipment of a car do not necessarily involve the rewinding of coils or armatures. In the main the work is of a purely mechanical nature, well within the scope of the average amateur's ability and workshop resources. In the absence of training in such work, rewinds and similar operations should be entrusted to specialists. But here again a correct diagnosis of the trouble, with removal of the faulty component for expert repair, will save time and money.

"What is electricity?" is a question that has baffled the world's greatest scientists, but it is now a generally accepted theory that electricity is the basis of all matter. This "electronic" theory holds that the atom itself comprises a "proton" or particle of positive electricity surrounded by millions of negative particles termed "electrons." The electrons revolve around their respective protons at some 1,000 miles a second and can be transferred from one atom to another. It is this transfer of electrons, caused by chemical or mechanical means, that constitutes an electric current—the basis of light and heat and power, whether for use in the car, the countryside or the home.

The earliest mechanical means of producing electricity was discovered by the ancient Greeks, who found that amber (from the Greek word "elektron") was capable, when rubbed, of attracting light materials.

To-day the mechanical production of electricity is entrusted to the dynamo, the alternator and the magneto. These will be examined in detail later.

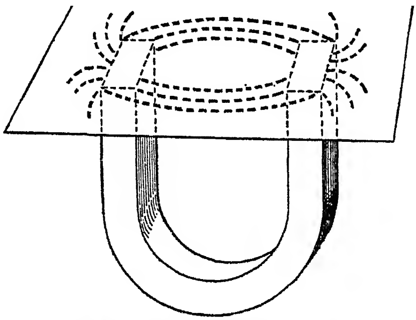
Where chemical action is responsible for the production of an electric current the apparatus used is the primary electric cell. It is not necessary to describe primary electric cells, of which there are many types, as they are not used in the modern car. A series of cells can be connected together to form a battery. The term "battery" however is now applied, in automobile work, to the special cells in which a chemical change is brought about by electrical means. Such a battery is then capable of being made to undergo a chemical change to produce an electric current.

The battery is one of the most important items of the car's electrical equipment and is fully described in a later chapter.

We must now consider electricity's "partner"—magnetism. And magnetism is of importance because upon it the generation of electricity, by mechanical means, partly depends.

Magnets are divided into two classes. There are permanent magnets, of steel or steel alloy, such as are used in magneto construction. Then there are electro-magnets consisting of coils of wire, either with or without an iron "core," that only function when an electric current is flowing through the windings.

Both types of magnet exhibit the same property of



Lines of force, as indicated by the dotted lines, can be shown by iron filings on paper held over a magnet.

attracting iron or steel and contain two "poles" designated north and south, respectively. Such poles show an attraction for the poles of the earth, which is, of course, in itself an enormous magnet.

The most important property of the magnet, however, is the existence of the "lines of force" that constitute a "magnetic field" in its vicinity. Lines of force can be observed by sprinkling iron filings on a sheet of paper held over a magnet, as shown in an accompanying drawing. The lines of force radiate in all directions and not merely in one plane. It should be remembered

also that both electro as well as permanent magnets may be either of the bar or the horseshoe types. Lines of force, however, are not only produced by an electric current flowing in a coil of wire, they are capable of producing an electric current also. When a coil of wire is moved in a magnetic field an electric current is produced in the wire by induction, discovered over a century ago by the famous scientist, Michael Faraday. This is the working principle of the dynamo and the magneto and of the great alternators that feed the electrical grids of this and other countries.

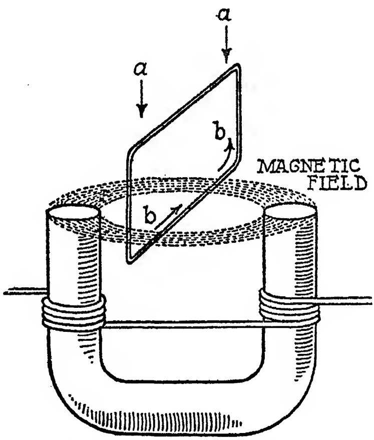
The dynamo produces a direct current (D.C.), whilst the alternator, as its name implies, generates alternating current (A.C.). The main differences between D.C. and A.C. should be noted. Briefly, direct current is that in which the direction of flow is constant, whilst an alternating current is built up from zero to reach a maximum in one direction and then falls to zero again: it then attains a maximum strength in the opposite direction and again falls to zero. This process, by the way, is quicker than its description would suggest. In England most of the A.C. mains supply is at 50 cycles (or changes) a second.

Now alternating current cannot be used for battery charging direct, and this is where the D.C. dynamo comes into its own. It is important to remember, however, that A.C. can be converted to D.C. by mechanical or chemical means, and there are numbers of excellent battery chargers on the market that can be plugged-in to the house or garage mains. Alternating current has, however, a great advantage over direct current in that it can be "transformed," that is its voltage can be increased or decreased readily to suit individual requirements. The high-tension A.C. supplied to the grid system by the power stations is taken to local transformer units for conversion to a voltage (usually 230) suitable for the house mains. We shall note later that the current generated by the magneto is alternating although coil ignition calls for the use of direct current.

From the mechanical point of view the main difference between the dynamo and the alternator is the method of taking the current from the coils of the revolving armature.

As one side of the armature coil moves upwards through the magnetic field the current flows in one direction, but on moving downwards the direction of the current is reversed. Consequently the current drawn off from the slip rings by the brushes changes its direction during each revolution of the armature. This is the principle that governs generation of alternating current.

For battery charging, however, and other uses on



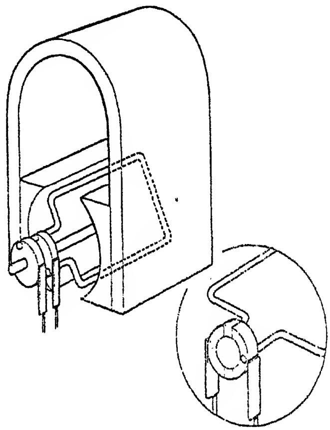
When a coil of wire is moved (as shown by arrows a, a) in a magnetic field, produced by a permanent or an electro magnet, a current is induced in the circuit (arrows b, b).

a car we require direct current. The slip rings accordingly are dispensed with and the dynamo is provided with a device known as a commutator, a kind of rotary switch attached to the armature shaft. The commutator has the effect of reversing the direction of the current delivered to the brushes, thus counteracting the current reversal due to the revolving of the

armature. In this way uni-directional or direct current is produced instead of alternating current. The simplest form of commutation is shown in the drawing, but it must be borne in mind that the armature of a dynamo has more than one coil and consequently more than one pair of segments to which the coil ends are connected.

In practice a third brush is often used to regulate output, and this system is described fully in the following chapter.

Before concluding the study of elementary principles

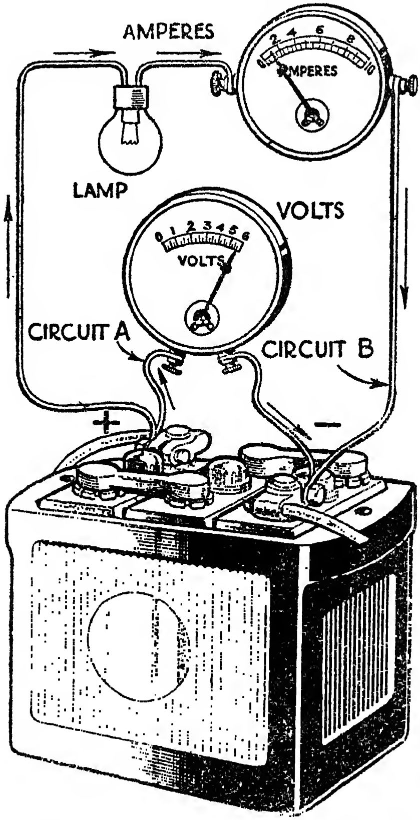


This very simple machine with slip rings and brushes would produce alternating current. By using a commutator (inset) the current becomes uni-directional.

we must consider some simple electrical circuits and the measurement of current flowing through them. It is well known, of course, that certain substances will permit the passage of an electric current and that others will oppose it. The former, known as conductors, include such substances as water, metals, carbon and the earth. Principal non-conductors comprise glass, rubber, paper, dry wood, mica and air.

When a conductor is placed across the terminals of

a generator or battery we have what is termed an electric circuit. The conductor may take the form of, say, the wiring and lamp filaments of the lighting circuit or the wiring and windings of the electric starter. In each instance the conductor provides a path for the



The voltage of a battery is checked by connecting a voltmeter (circuit A) across the terminals whilst the current taken by a lamp is measured by connecting it in series with an ammeter (circuit B). An ordinary ammeter should never be connected directly across the battery terminals.

current to pass from the negative terminal of the generator, or battery, to the positive terminal. In the case of the lamp filament a strong resistance to the passage of the current results in heating to incandescence and the production of light: in the starter circuit the current is turned into mechanical energy.

A typical electric circuit is illustrated by the diagram. This shows a battery with a lamp and ampere-meter (or ammeter) connected "in series," that is to say both form part of the circuit. The ammeter is not essential to the circuit, but provides a ready means of ascertaining the amperage or "rate of flow" of the current. Across the terminals of the battery are "shunted" the leads of a volt-meter. The volt-meter, which is said to be "in shunt" with the battery terminals, does not form part of the circuit but registers the voltage or "pressure" of the current.

The flow of current in an electrical circuit is governed by a law propounded by the great scientist Ohm. Ohm's law states that a current of 1 ampere at a pressure of 1 volt will overcome a resistance of 1 ohm. The ohm is the standard unit of resistance. Ohm's law is expressed in the formulæ:—

$$C = \frac{E}{R} \text{ or } R = \frac{E}{C} \text{ or } E = CR$$

where C = current in amperes.
E = electromotive force (E.M.F.) in volts.
R = resistance in ohms.

In addition to the volt, ampere and ohm there is another unit to be considered. This is the watt, obtained by multiplying the voltage by the amperage in a circuit, and it represents the consumption of electrical energy. The watt is named after the great engineer, James Watt, and one kilowatt (1,000 watts) is equivalent to $1\frac{1}{3}$ horse-power.

CHAPTER II.

Dynamos.

WE have discussed the general principles on which dynamos work and we now have to consider the main types of dynamo used on cars. It should be understood that the modern dynamo is not a particularly complicated mechanism and if reasonably treated will very seldom give any trouble.

Generally, the car dynamo comprises a cylindrical casing inside which the pole pieces are attached by countersunk steel screws. Surrounding these poles are the field coils that supply the magnetizing current. The casing is fitted with end covers that contain the armature bearings.

The armature is the revolving portion of the dynamo and consists of a number of slotted soft-iron stampings. These are assembled on the armature spindle with the slots so arranged that they form either straight or spiral grooves. Insulated wire is wound into these longitudinal grooves and the ends of the coils are attached to the bars of the commutator at one end of the armature. The carbon brushes that bear on the commutator and collect current both for the dynamo fields and the external circuit are carried in holders attached to one of the end covers.

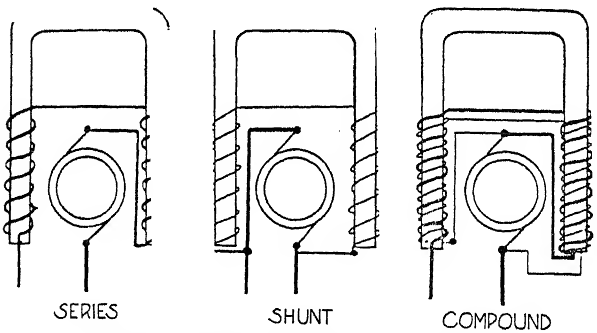
Armature winding is a somewhat tricky job and is best left to an expert should repairs become necessary. The windings must be fixed rigidly in place to resist the effect of centrifugal force when the armature is revolving at high speed. It is essential also that the armature be balanced so that it runs without vibration. The bearings must be maintained in good condition.

Extreme accuracy is essential in armature construction because the clearance or air gap between the stampings and the field pole pieces is very small, usually only a few thousandths of an inch.

Dynamo Types.

There are three types of dynamo known, according to the way in which they are wound, as series, shunt and compound. In a series-wound dynamo one terminal is joined to one end of the field windings, usually two or four in number. The field windings are continuous and the free end is attached to one of the brushes. The second brush is connected to the other terminal.

This type of dynamo is now obsolete, as it is incap-



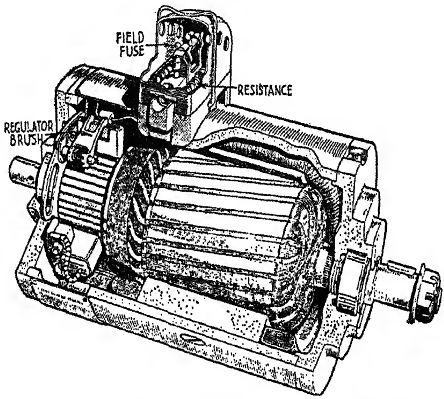
The three principal types of dynamo windings.

able of maintaining a steady output in all conditions of speed and load. The compound-wound dynamo overcomes the difficulty of maintaining output despite variations in load. In the compound machine one terminal is connected to one brush and to one end of the field windings, the other end of which is connected to the second brush.

In addition to the shunt field windings, secondary field windings are inserted in series with the armature. The provision of this series field coil compensates for

the drop in voltage when the load on the dynamo is increased.

It is the shunt-wound type of dynamo that is used on cars, because it has the advantage of building up quickly to its full output and is, to a certain extent, self-regulating. In the normal type of shunt-wound dynamo the brushes are connected one to each terminal and the terminals are also connected to the ends of the field windings. We have noted that the shunt-wound dynamo is self-regulating to a certain extent. This type of machine, however, is not entirely suitable for use on cars because of the considerable speed variations to



A typical dynamo, showing the regulator (third) brush, resistance housing, armature and field windings.

which it is subjected. The self-regulating properties of the shunt dynamo are insufficient at high speed.

It becomes necessary, therefore, to modify the design of the shunt dynamo to provide for the regulation of output within a wide range of engine speeds.

Controlling the Output.

A very simple method of providing accurate control of the voltage consists of adding another brush and

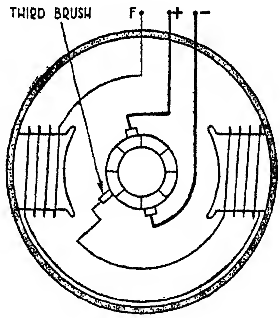
arranging the connections so that it is wired to one end of the field windings. The other end of the windings is joined to a main brush, from which a connection leads to a terminal on the dynamo casing or end cover.

The second main brush is also connected to a terminal.

The third brush controls the output by progressively weakening the magnetic field as the speed rises. Variation in output can be obtained in most dynamos by altering the position of the third brush, which is mounted in a movable holder.

Third-brush Setting.

With the engine and, therefore, the dynamo at normal running temperature, open the throttle, with the gear in neutral, to a point where the engine revs. represent



This diagram indicates the connections in a third-brush dynamo of average type.

about 30 m.p.h. The dynamo should then be generating its full output. If it is not, open the throttle a little more.

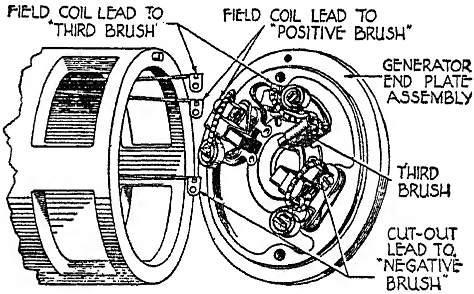
Switch on all the lights—head, side and tail—and note the reading of the ammeter; it should show a small amount of charge—about 2 amps. or a little less. If the needle is on the discharge side of zero, move the third (regulating) brush of the dynamo, as required, to obtain 2 amps. charge. Alternatively, if a charge of

rather more than 2 amps. is shown in this test the output must be reduced, as it will be too great when the lamp load is removed.

It is assumed, of course, that bulbs of standard wattage are used. If "oversize" head lamp bulbs be fitted—taking, say, 2 amps. more than normal—one should be content with a zero ammeter reading on full load, i.e., no "charge" and no "discharge," otherwise during daylight running the battery will receive an excess charge.

The method of arranging for brush movement varies with different dynamos. Sometimes there is a locking screw (or two screws) working in a curved slot in the end cover. The brush can be moved after slacking the screw (or screws) very slightly.

In another design part of the brush carrier is formed



The third brush system of output control showing relation of the third brush to the main brushes.

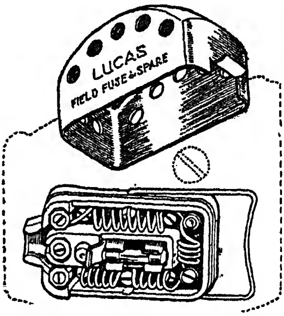
as a toothed segment, with which meshes a small pinion. A hexagon on the pinion enables it to be rotated with a spanner, thus moving the brush. A locking screw in the end cover prevents movement at the wrong time. There is a further scheme in which the brush carrier is frictionally held, so that only a fairly hard push is needed to move the brush.

On some types of dynamo the current can be further regulated by means of a hand-operated switch, which introduces resistances into the circuit. As a rule there

are two switch positions, "charge" and "half-charge." In the "charge" position the normal output of the dynamo is allowed to pass; for "half-charge" the amperage is reduced to approximately half the full rate. An additional resistance, which remains in circuit until the lights are switched on, may also be provided. By this means an excessive "daylight" charge is avoided, but the output is boosted up when the lamp load comes on.

Field-circuit Fuse.

In spite of third-brush governing, a voltage beyond the safety limit may be generated in certain circumstances; its effect would be to burn out the field coils, which are therefore provided with a fuse. On modern



Dynamo field fuse, charging resistance and spare fuse.

cars there are fuses also in the lamp circuits, but these have no direct effect upon the dynamo.

The field fuse will blow only if a fault develops in the main circuit, and it is a mistake to replace the fuse without finding the cause of its blowing. It is an even greater mistake to substitute a heavier-gauge fuse wire to prevent blowing. A fuse is a safety valve set to blow at a certain pressure, and any attempt to increase the "strength" of the fuse may lead to trouble.

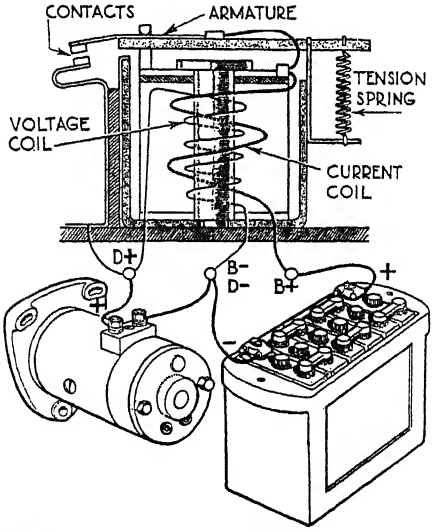
If a dynamo and a battery be connected together and the dynamo be stationary or running below its charging

speed, the battery will feed back through the dynamo. This, of course, will result in the battery being discharged; therefore, a switch must be placed in the circuit so that the current can be cut off whenever the dynamo is not generating.

Continuously to operate the switch by hand would be troublesome and uncertain, but it is quite easy to provide an automatic switch worked by the battery and the dynamo.

Automatic Cut-out.

Practically all cars have a switch of this kind, and it is known as a cut-out. Its construction and working,



A normal[1] type of cut-out, showing the various connections to the dynamo and the battery.

are very simple. A soft-iron core carries two windings. One, the voltage coil, is of fine wire with its ends connected across the dynamo terminals, whilst the other, of thicker wire and known as the current coil, has one end connected to the positive battery terminal.

The other end is led out to a hinged soft-iron armature, which passes across the top of the core and carries a contact on its free end.

The opposite, or fixed, contact is mounted on—but insulated from—the cut-out frame and is connected to the positive dynamo terminal. A tension spring holds the contact apart when no current is flowing in the coils.

The action of the cut-out is as follows: When the dynamo is working a current flows through the voltage coil and magnetizes the core. The magnetic pull attracts the armature, causing it to overcome the tension of the spring; thus the contacts close and allow the dynamo current to pass to the battery via the current coil. This increases the magnetic pull on the armature, so that the contacts are firmly pressed together, thus providing a free path for the current.

So long as the dynamo is running at charging speed the contacts remain closed, but when the voltage falls below that of the battery, as when the dynamo begins to slow down, the current reverses, passing from the battery to the dynamo. Thus there are two opposing currents acting on the cut-out windings, and their effect is to demagnetize the core. This allows the armature to spring up so that the contacts open and stop the flow of current from the battery.

Cut-out Adjustments.

The contact adjustment must be very accurately set if the cut-out is to work properly. Generally, the contacts close when the current reaches about .5 amp. and open when a reverse current of similar value passes.

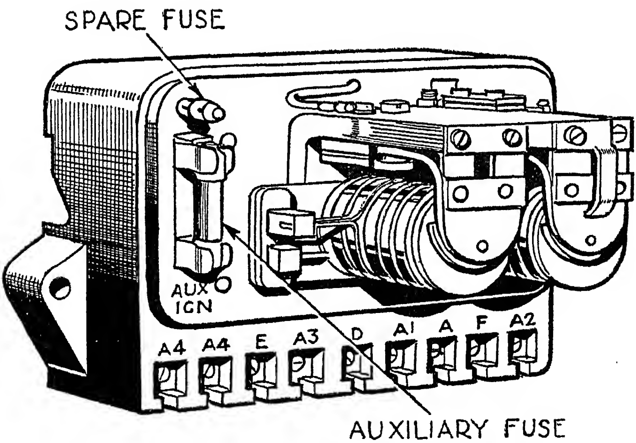
It is not advisable, as a rule, for amateurs to interfere with the mechanism of a cut-out, and for this reason the instrument is nearly always protected by a sealed cover. Faults which can develop in a cut-out may consist of burnt-out windings, burnt or pitted contacts or a sticking armature, due to the pull-off spring having weakened.

If the cut-out cover is not sealed, or if one cares to

break the seal (possibly invalidating the guarantee), minor defects can often be made good by the exercise of a little skill and care.

Burnt contacts can be trimmed by the use of a contact file rubbed between them whilst the armature is pressed down gently. After trimming it is necessary to see that the two points come together fully before the armature touches the cut-out core. Actually, with the points touching there should be a gap of .015 in. or so between the armature and the core.

A word of warning is necessary here. Before touching the cut-out contacts the battery leads should be



The Lucas cut-out, regulator and fuse box.

disconnected from the terminal posts; merely turning the charging switch to "off" is not sufficient, as it breaks only the dynamo-field circuit.

A weakened pull-off spring is an unlikely fault, but one not easily rectified, except by fitting a new spring obtained from the makers, as it is very difficult to find the correct tension by experiment.

In the case of burnt-out windings, a rewind is beyond

the scope of most amateurs, and the makers should be consulted.

Momentarily sticking of the contacts, by the way, can sometimes be overcome by jarring the casing; the fact that they have separated will be indicated by the needle of the ammeter returning to zero.

It must be understood that a cut-out is simply a safety switch which connects the battery to the dynamo for charging purposes, but it does not disconnect it when a state of full charge is reached; thus, it is possible, in certain circumstances, to overcharge the battery; that is, to supply it with more current than it needs. This may result in the plates being damaged.

A battery can be maintained in perfect condition only when it receives a properly regulated charge, and this is a requirement which a dynamo of the third-brush type cannot fulfil.

Voltage-regulator Systems.

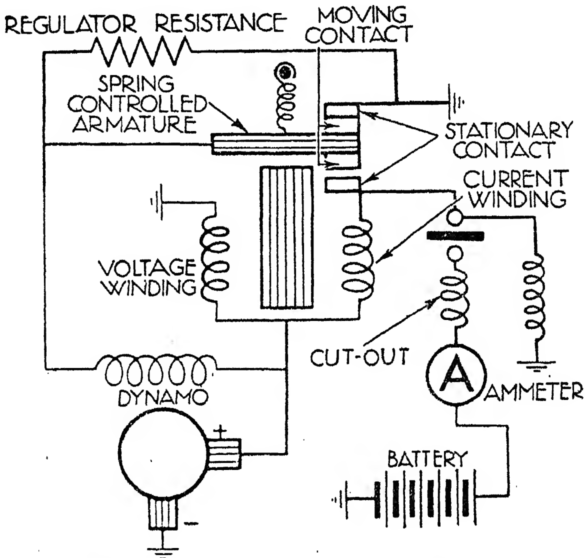
There is, however, a special form of dynamo—to be found on many modern cars—which regulates the charging current very precisely. The machine has been developed over a number of years in connection with commercial vehicles, where the demands upon the battery are particularly heavy; it may be taken, therefore, that the perfected system, now applied to private cars, is entirely satisfactory and reliable.

The dynamo is similar to a third-brush machine in external appearance, but it is wound differently and the third brush is omitted. There are, in fact, only the two main brushes—positive and negative. The output of the dynamo is controlled by a regulator unit which may be housed at any convenient point on the car, such as the dashboard, and has combined with it a junction box and a fuse box.

The regulator causes the dynamo to give an output which varies according to the state of charge of the battery. If the battery be discharged the dynamo gives a high output, so that a normal state of charge is reached in a minimum time. If, however, the battery

be fully charged, the regulator cuts down the dynamo output, so that only a trickle charge passes to the battery, just sufficient to keep it in good condition without risk of causing damage by overcharging.

In addition to controlling the rate of charge of the battery, the regulator provides for an increased dynamo output to balance the current taken by the lamps or other accessories whenever they are in use.



Wiring diagram of the Lucas voltage regulator with which a two-brush dynamo is used.

On most cars the regulator system is set to provide a suitable current output at a road speed of about 20 m.p.h. Thereafter, irrespective of speed, the current supplied to the battery will be in accordance with its state of charge, so that the ammeter may show a high reading just after starting from cold and fall to only 2 amps. or 3 amps. when the car has been running for 10 minutes or so.

Principle of the Regulator.

The essential portion of the voltage regulator consists of two windings through which passes a core or armature. This armature actuates a pair of contacts which serve to short a resistance in the field circuit. The contacts are held closed by means of a spring when the regulator is not working.

The windings consist of a voltage coil, connected directly across the dynamo terminals, and a current coil, which carries the full current from the dynamo to the battery.

When the dynamo voltage reaches a predetermined figure the magnetic field set up by the voltage coil becomes sufficiently strong to attract the armature. This causes the contacts to open, thereby inserting the resistance in the field circuit.

The resulting reduction in field current naturally lowers the dynamo voltage, and this, in turn, weakens the magnetic field set up by the voltage coil; thus the core is allowed to return to its original position where it closes the contacts and so allows the voltage to rise to the predetermined maximum. The cycle is then repeated, and so rapid are the changes that the core is set into vibration.

As the speed of the dynamo rises above that at which the regulator comes into operation—about 20 m.p.h.—the amplitude of vibration increases and the periods of interruption increase in length, with the result that the mean value of the dynamo output undergoes practically no increase once the operating speed has been attained.

The current coil of the regulator provides a means for compensation, as without it there would be a risk of overloading the dynamo when the battery is in a low state of charge. The winding assists the voltage coil, so that when the dynamo is delivering a heavy current into a discharged battery the regulator comes into operation at a somewhat reduced voltage and limits the dynamo output accordingly.

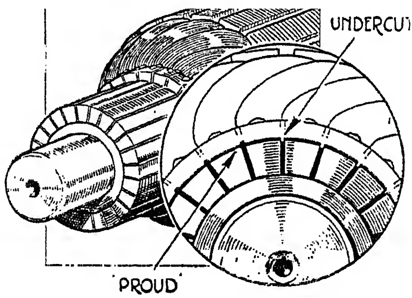
A cut-out of the type already described in this chapter

is used in conjunction with the regulator, but neither piece of apparatus requires attention from the owner of the car; they are, in fact, sealed. An adjustment is, however, provided on the regulator unit, so that alterations in its controlling function can be made at a service station.

Dynamo Maintenance.

Dynamos, whether of the voltage-regulator or third-brush type, require a little maintenance attention from time to time, and this is mostly in connection with the commutator and brush gear.

After long service the armature will become blackened on its surface and, perhaps, scored slightly, whilst the mica strips which insulate each of the commutator bars or segments may tend to project slightly above the general surface. These are conditions which lead to



Projecting or "proud" commutator micas prevent proper brush contact. They should be undercut slightly.

faulty working, as the projecting micas prevent the brushes from making proper contact with the commutator bars, and this, whilst cutting down the output, will also lead to bad sparking, with consequent burning of the commutator and the brushes.

The mica strips can be cut down by careful manipulation of a suitable tool, such as a very fine hacksaw blade, but it is necessary, of course, to remove the

armature from the dynamo casing in order to gain access to the commutator.

This is a job, however, which any reasonably skilful amateur can undertake. It is first necessary to remove the dynamo from the engine, bearing in mind that, where a coil distributor is driven by skew gearing from the dynamo spindle, retiming will be necessary upon replacement; therefore the teeth of the driving gears should be marked.

Commutator Reconditioning.

On the bench the armature can be withdrawn by unscrewing the cover at the driving end of the machine and pulling it clear. Care must be taken, however, first of all to withdraw the brushes from their holders and to make sure that they cannot be replaced incorrectly. With the armature out, the commutator can be examined and if the micas must be cut down it should be clamped gently in a vice, the jaws of which are protected by lead or fibre clamps. A very steady hand is needed for cutting the micas, because if the cutting tool slips it will score the copper.

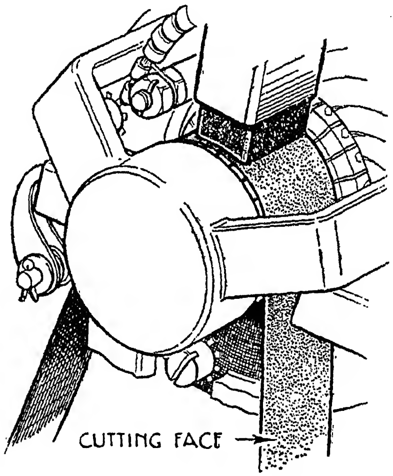
If a lathe is available it is an excellent plan to mount the armature between the centres and to bolt a very narrow parting tool sideways in the tool holder, so that when the saddle is moved along the bed the tool will operate on the mica after the fashion of a planer.

Only a slight undercut is necessary; that is to say, the mica strips should lie about 1/32 in. below the copper surface. The bottom of the cut should be square and not V-shaped. When the cutting is finished the surface of the commutator can be polished by use of very fine glass paper. Emery cloth should never be used as the grains of emery may bed themselves into the commutator and cause rapid brush wear.

If the armature is badly pitted or burnt it may be necessary to skim it up in a lathe, but a very fine cut should be taken—only just sufficient to remove the pitting. Naturally, if this be necessary, it will be done before the micas are undercut.

When the armature is refitted to the dynamo it will be necessary, in all probability, to bed-in the brushes on the new commutator surface. Their working faces should first be examined, and if they are bright with fairly clean-cut edges they will require very little attention, but chipping or pitting will indicate the need for resurfacing.

The best way to do this is to pass a strip of fine glass-paper around the commutator with the cutting surface outwards. Each brush in turn is then slipped into its



Brush faces can be curved to the commutator radius by the use of a strip of glasspaper arranged as indicated here and pulled to and fro.

holder with the spring pressing on it and the glasspaper pulled backwards and forwards around the radius of the commutator. This will cut the brush surface to the correct curve, as the thickness of the glasspaper may be disregarded.

When all of the brushes have been treated in this manner a soft-haired brush should be used to clear away all traces of carbon dust, which might otherwise cling to the brush holders and set up short circuits.

CHAPTER III.

Batteries.

THE battery may well be described as the most important item of a car's electrical equipment. The source of supply for a dozen or more different purposes, the modern battery is remarkably efficient in operation and requires but little attention to maintain it in perfect working order. Unfortunately, batteries are usually stowed away out of sight and consequently they are also out of mind only too often. And neglect in battery maintenance leads to trouble on attempting to start the engine or on the road, with the certainty of heavy repairs or costly replacements sooner or later.

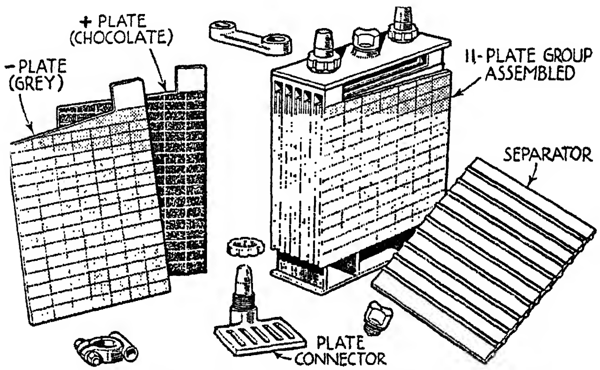
Most battery faults can, however, be guarded against and a routine inspection amply repays any trouble involved. Car batteries are of two main types, one in which lead plates are used, the other employing nickel iron. Generally, however, batteries are of the lead acid type, comprising a number of cells, in each of which are two groups of lead plates immersed in an electrolyte, or conducting liquid, of diluted sulphuric acid. The lead plates are in the form of perforated grids, the holes in which contain oxides of lead.

One group of plates, the positive, is loaded with lead peroxide, whilst the other group, of negative plates, contains a paste of pure lead known as spongy lead. In each cell of the battery the plates of the negative group alternate with the positive plates. It is, of course, essential that plates of opposite groups shall not touch each other and they are accordingly held apart by separators of non-conducting material.

The two groups of plates in each cell are joined by

lugs to their respective terminals. A cell thus comprises a complete unit having one negative and one positive terminal. Cells are connected in series, with the negative terminal of one cell joined by a lead bar to the positive terminal of the next. The remaining positive and negative lugs of the end cells form the main output terminals of the battery.

The battery casing is usually of moulded composition and the cells are sealed with a non-conducting compound, leaving, however, a vent hole for the



The components of a single cell forming part of a car battery.

escape of gases and for periodical "topping up" or addition of distilled water to the electrolyte.

Chemical Action.

A car battery is often referred to as a storage battery, but this term is not strictly correct as the cells do not store electricity, they only yield an electric current through chemical action. Such action is a reversal of the process carried out when the battery terminals are connected to those of a dynamo for the purpose of charging.

When a battery is being charged the current splits up the water content of the electrolyte into its two constituents, hydrogen and oxygen. These two gases form

an explosive mixture and for this reason a naked light should not be taken near the battery.

The hydrogen combines with the lead sulphate of the negative plates to form sulphuric acid, which is, of course, absorbed into the electrolyte, whilst the negative plates are left in their original form—pure lead. At the same time the oxygen which is freed by the charging current attacks the lead sulphate of the positive plates. Thus the lead sulphate, with the free oxygen and the water of the electrolyte, produces lead peroxide (the original positive plate content) and sulphuric acid.

On discharging the battery the above process is reversed; the lead peroxide (positive plates) and the pure lead (negative plates) are each changed into lead sulphate, whilst the surplus hydrogen and oxygen unite to form more water which is automatically absorbed into the electrolyte.

It is this alteration of the water content of the electrolyte that enables the state of charge of the battery to be ascertained readily by the use of a hydrometer.

Testing the Electrolyte.

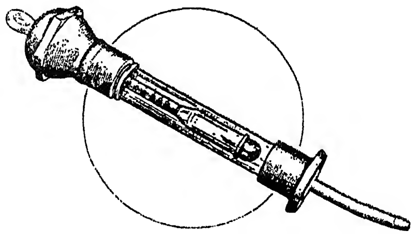
A hydrometer works on the principle that a heavy liquid will support a floating object of greater weight than will a lighter liquid. To take an extreme example, a piece of iron will float in a bowl of mercury but will sink in a bowl of water.

The hydrometer comprises a closed glass tube so weighted at one end that it will float upright in the electrolyte of a battery. We have seen that as the battery is discharged water is absorbed by the electrolyte, which thus acquires a lower specific gravity. A liquid's specific gravity is its weight compared with that of pure water at a temperature of 60 degrees Fahrenheit.

When fully discharged, therefore, the battery's electrolyte will allow the hydrometer to sink to its fullest extent and a mark on its stem will correspond with the surface of the electrolyte and so indicate the condition of the battery. At full charge, with the electro-

lyte rendered more "acid," the float will rise to its highest point and another mark on the stem thus indicates the battery's condition. An intermediate mark on the float stem gives a reading at half charge. Some hydrometer floats are marked with graduations that give direct specific gravity readings. The specific gravity of the electrolyte in a fully charged battery is usually from 1.250 to 1.280 and 1.150 to 1.180 when fully discharged.

It is not practical to insert the float in turn in the battery cells. Accordingly, an electrolyte testing hydrometer usually consists of a float contained within an outer glass tube provided with a rubber bulb at one end and a thin nozzle at the other. After having inserted



A typical form of hydrometer with which the density of the electrolyte can be tested.

the nozzle through a cell vent, the bulb is squeezed and released so that a portion of the electrolyte is drawn up into the glass tube. The float will then indicate the specific gravity of the "sample" electrolyte which is duly returned to the cell, leaving the instrument ready for testing the next compartment.

In some hydrometers the float is replaced by three coloured beads of different weights that float or sink according to the state or charge.

Battery Capacity.

We have seen that the condition of the electrolyte indicates the degree to which a battery has been charged and this brings us to considerations of capacity.

The capacity of a battery is governed by the surface

area of the plates and is measured in ampere-hours. For example, a battery with a capacity of 50 ampere-hours is capable of supplying a current of, say, 5 amps. for 10 hours or 2.5 amps. for 20 hours. It does not follow, however, that 50 amps. represents the heaviest current the battery can supply. Modern car batteries are so constructed that a 50 ampere-hours capacity will permit of a 200 ampere output momentarily, as may be necessary for the operation of the starter motor. It should be remembered that the amperage of a battery is dependent on its state of charge; obviously, it cannot be expected to yield its full output unless fully charged. And because amperage is also dependent on plate area exposed to the electrolyte it will be appreciated that plates must be fully immersed for efficient operation.

The difference between amperage and voltage has been referred to in the first chapter of this manual. The voltage of a battery cell cannot exceed 2.5 irrespective of the size or number of the plates. Voltage does not vary with the state of charge to the same extent as does amperage and, consequently, a volt meter reading across the terminals of a cell is not a reliable guide to the condition of the battery.

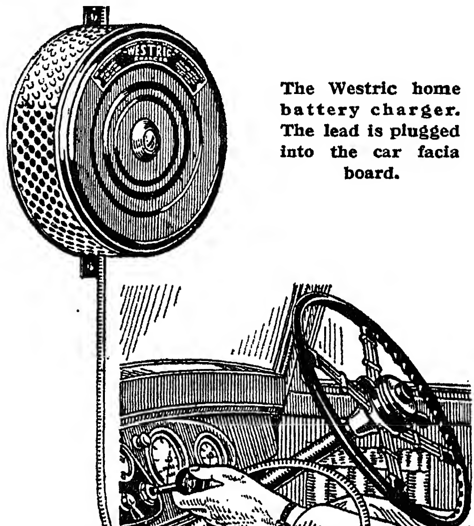
A discharged cell shows a reading of 1.8 volts, which on charging rises quickly to 2 volts and to 2.3 volts. At this figure the voltage remains constant until the charge is nearly completed and the reading then mounts rapidly to 2.5. The total voltage of the battery, with its cells connected in series, is the sum of the individual cell voltages. Car batteries are usually of the 6 or the 12-volt type.

It is claimed for the 12-volt system that, as only half the current (amperage) is required, wiring and fittings can be of lighter materials. Voltage drop, due to resistance, in a 12-volt circuit is of less consequence than in a 6-volt installation.

Advantages of 6-volt working include lighter and cheaper batteries with fewer cells requiring attention. The filaments of 6-volt lamps are only one-fourth the length of 12-volt filaments and are consequently stronger.

In comparing 12 and 6-volt installations it must be borne in mind that the output of the battery for lighting and other purposes is not dependent on the voltage but on the voltage multiplied by the amperage, that is the number of watts produced. By adjusting the plate area, the amperage can be varied so that a 6-volt battery will yield as much "power" (measured in watts) as one of the 12-volt type.

From the practical standpoint there is little to choose between the 6 and 12-volt installations, and although



The Westric home battery charger. The lead is plugged into the car facia board.

higher priced British cars are usually equipped with 12-volt batteries, reasons of economy and all-round efficiency have led most manufacturers to use 6-volt circuits for their lighter cars.

Battery Charging.

Charging and charging methods rank among the most important considerations in battery maintenance. For

example, it is imperative that in no circumstances should a battery be allowed to remain in a discharged condition. We have noted that when a cell is being discharged the plates become sulphated, a necessary part of the chemical action. When, however, the battery is fully discharged this sulphation of the plates continues, the sulphate clogs up the pores of the plates (to the exclusion of the electrolyte) and becomes hard. After hardening the sulphate offers considerable resistance to the charging current, which has therefore to be much reduced. Further, charging at the reduced rate has to be continued for a long time to avoid undue heating. It will be appreciated that excessive sulphation must be avoided by timely recharging of the battery. Charging should be carried out at the rate recommended by the makers, but, should this not be known, the amperage of the charge may be based on one-tenth of the cells' capacity in ampere-hours. A 50 ampere-hour battery should be charged, therefore, at 5 amperes.

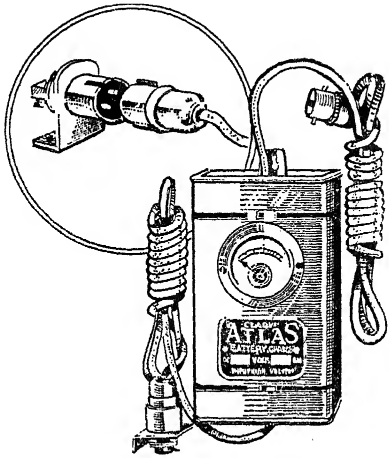
Another point to watch in maintenance is that of keeping the battery fully charged. This may not always be possible by using the dynamo alone as such charging is dependent on the running of the car. Obviously, long daytime non-stop runs will benefit the battery much more than night rides with consequent use of the lighting system.

The remedy is to give a long, slow charge from an outside source, and this course is to be recommended in any event as the treatment results in longer life for the battery.

Mains Chargers.

A very convenient method of battery charging is to use a mains charger, of which there are a number of makes on the market. In most instances house mains supply alternating current, usually at 230 volts and with a periodicity, that is the rate of charge in direction, of 50 cycles (or changes) a second. The charger is connected to the mains supply and is secured in a convenient position on the garage wall. A special socket is attached to the dashboard and its terminals are

connected with the battery circuit. To charge the battery it is only necessary to "plug-in" a lead from the charger to the dashboard socket. The type of battery charger operated from A.C. mains comprises a transformer and a device termed a rectifier that changes the fluctuating alternating current into one that flows in one direction only. This condition is essential for battery charging and the rectifier consists of a number of specially treated



The Atlas battery charger, complete with non-reversible dashboard plug and circuit connection.

metal plates that permit the passage of current in one direction only. Alternatively, the current may be rectified by the use of a liquid (electrolytic rectification) or of a valve similar to those employed for radio purposes. Charging can also be carried out by using a D.C. dynamo driven by an A.C. motor.

Charging from direct current mains is less complicated but not so economical in operation. Direct current cannot be "stepped-down," like alternating current, by a transformer, and for battery charging the necessary reduction in voltage is obtained by using

a resistance in the circuit. The resistance may comprise a group of carbon filament lamps arranged in parallel but placed in the circuit in series. As a guide to the amount of current passed by these lamps, a 32-candle-power lamp on a 230-volt circuit will take just under .5 amp. By adding the requisite number of lamps in parallel a corresponding rise is obtained in the rate of charge.

The best use of direct current charging can be made when the resistance consists of an engine or radiator warmer. Overnight charging is more necessary in winter than in summer so that the surplus heat of the resistance can be turned to good account by maintaining a reasonable temperature beneath the bonnet in frosty weather.

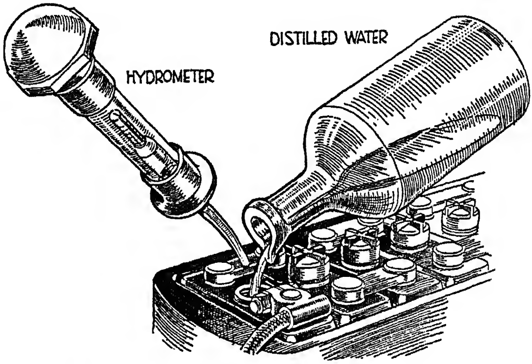
Maintenance and Repairs.

We have noted the more important aspects of battery maintenance, namely, "topping up" the electrolyte and keeping the cells fully charged by occasional charging from an outside source. There are, however, a few additional points to be noted in connection with the electrolyte, charging rates and conditioning of plates and terminals. Topping up the cells with distilled water is simply the replacing of water lost by electrolysis. Sometimes it is necessary to replenish electrolyte that has been spilled. The electrolyte must consist only of the purest brimstone sulphuric acid (not commercial acid) and distilled water. It is imperative that the acid be added *to the water* and very slowly. Addition of water to the acid gives rise to great heat with the possibility of dangerous consequences. The proportion of acid to water is approximately 1 to 3 and the specific gravity of the electrolyte should be tested with a hydrometer before use.

A point to watch when charging from the mains or other outside source is the rate of charge. Violent "gassing" of the cells is an indication that the charging rate is too high and it should be cut down accordingly, or damage will result to the plates, separators and battery casing.

It is evident that one terminal of a battery must be "earthed" to the chassis to provide a return path for current from the numerous electrical devices on the car, which are also duly "earthed."

At one time it was the negative terminal of the battery that was earthed, but a modern tendency is to use a positive earth, a method that provides a number



Topping up with distilled water and periodical hydrometer tests are essentials of battery maintenance.

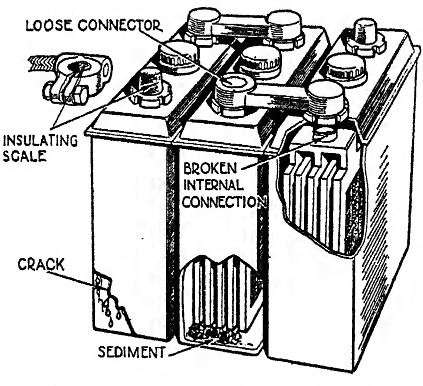
of advantages. With coil ignition a positive earth results in the protection of the distributor rotor arm from a tendency to burn. The risk of burning is, in fact, transferred to and spread over four or more electrodes. Similarly, with sparking plugs, positive earthing renders the central electrode negative and it shows less tendency to burn away; in addition, a lower sparking voltage is required and the chance of misfiring on light load is reduced.

Positive earthing also plays an important part in the prevention of terminal corrosion. With negative earthing, electrical leakage due to acid spray can occur from the positive terminal to the car frame, to metal fittings near the battery, and from the positive terminal to the negative. These leakages tend to set up corrosion of the positive terminal but not to the negative, which is subject only to less serious direct chemical corrosion.

With an earthed positive, however, there can be no leakage and a cause of corrosion is thus eliminated. Terminals that have become corroded should be scraped with a knife and cleaned with strong ammonia. Terminal posts should be smeared lightly with vaseline before replacing the clips.

Dismantling the Battery.

The complete dismantling of a battery is generally regarded as work best left to the expert. But a bad casing crack, broken internal connection, or too much sediment from the plates may render it necessary, in default of garage assistance, for the owner-driver to undertake this work for himself. The sealing pitch round the top cover of the battery can be softened for easy removal by a jet of steam. A tin can over a



Common causes of battery failure are indicated above.

Bunsen burner, with a length of copper tubing soldered into the lid, may be used for the supply of steam. With the top cover released, the plates can be prised up by screwdrivers with the ends under the terminal nuts, using pieces of wood on the casing top as fulcrums. The acid can then be decanted off and the casing can be washed clean. Cracks may be repaired with pitch and broken internal connections must be made good with lead strip or rod.

Alkaline Batteries.

Although the lead-acid battery has proved quite capable of supplying the requirements of most motor vehicles, especially private cars, an interesting alternative is provided by the alkaline battery. This type of battery will stand considerable rough use, being constructed of steel throughout. A steel casing contains perforated steel plates that hold the active material. The positive plates contain nickel hydroxide which is reduced to what is termed a "lower" oxide on discharge. Negative plates are filled with cadmium and iron, reduced on discharge to their respective oxides. On charge the action is reversed with the transfer of oxygen from one set of plates to the other. The electrolyte consists of potassium hydrate in distilled water and the specific gravity of this solution remains constant during charge and discharge of the battery.

Alkaline batteries require but little attention and can be left uncharged without damage. The individual cells, however, only give 1.2 volts and because more of them are required as compared with a lead acid battery there is little saving in weight. Alkaline batteries are also somewhat expensive in first cost. For heavy commercial vehicles the alkaline battery offers great advantages in complying with difficult working conditions.

CHAPTER IV.

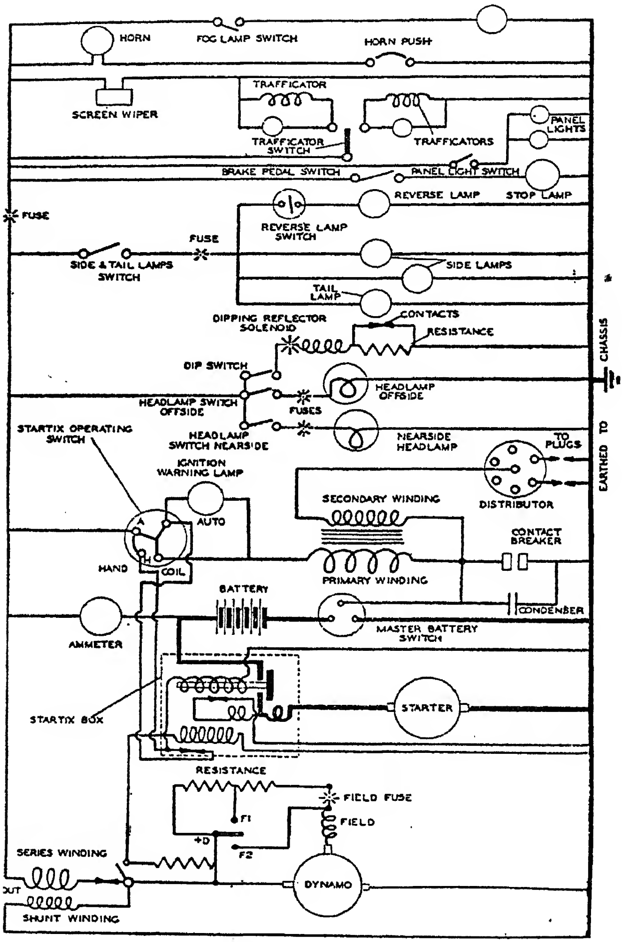
Wiring.

THE electrical wiring of the modern car with its frequent addition of new appliances presents a very complicated appearance, but if considered in detail the various circuits will be found relatively simple. Wiring in automobile work presents its own problems, one of which is the necessity for using varying sizes of wire for different purposes. All equipment has to be connected up to the source of supply, the battery, by suitable wires.

Some components—the starter motor, for example—need heavy-gauge leads to cope with the large current necessary for their operation. A starter motor may take momentarily some 200 amps. It is obvious that the same type of wire would not be suitable for all equipment, hence the necessity for using different gauges of wire.

The cables of a car have to withstand the effects of oil, heat, wet and vibration. Manufacturers have produced cables which in ordinary circumstances are unaffected under these conditions.

Well secured to prevent any unnecessary movement and consequent fraying, cables should not require much attention during the life of the car. An understanding of wiring will, however, save considerable trouble should faults develop. It must be remembered that it is always necessary to use wire of a size capable of carrying the full current of all components in its circuit. Too heavy a gauge, however, involves unnecessary expense. The insulation must be sufficient to prevent "shorting" or leakage of current to the chassis or



A Lucas wiring diagram applying to a six-cylinder car. Note the connections for the battery master switch.

"earth," and the outer casing must be proofed to withstand working conditions.

Any cable carried beneath the car, for example, must have not only good insulation, but must also be thoroughly waterproof. But a wire from, say, the ammeter to a dashboard light may be ordinary flex as used for house lighting.

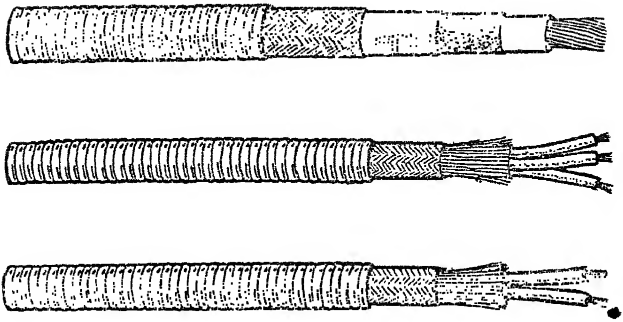
The current-carrying capacity of a cable is determined by the size and number of strands of wire of which it is made. A cable known as 35/30, for example, is one that has 35 strands of wire each of 30 s.w.g. (standard wire gauge). A cable of this size is sufficient to carry the full dynamo current or to supply a high-frequency horn.

Smaller cables, such as 14/30, are sufficient for, say, fog or road lamps, and ordinary house lighting flex suffices for a small inspection lamp. Sometimes 36/33 wire is recommended for coil ignition circuits.

Insulation.

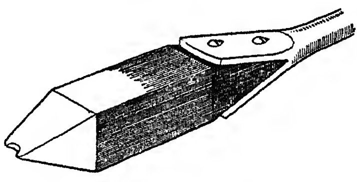
The type of insulation required depends on the current passing through the cable and the conditions to which it is exposed. The essential part of the insulation consists of vulcanized rubber. This is usually provided with a proofed braided casing with a cellulose or lacquer varnish coating, which resists petrol, oil and water. Some cables have a black polished petrol and oil-proof casing, which does not crack when bent. This is not so strong as armoured cable, but is adequate for some jobs.

Armoured cable usually has a thin strip of soft metal, such as brass or aluminium, wound round the rubber insulation as an extra protection, such as would be required in a position beneath a mudguard where mud and grit are flung about. When armoured cable is used care must be taken to see that the casing is cut back at least ½ in. from any terminal to which a connection is made, as with the earth return system a dead short circuit would occur should the casing come in contact with a live terminal.

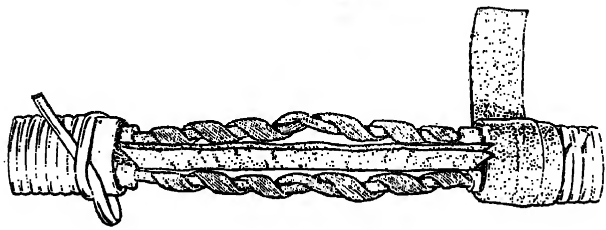


Types of cable used on car wiring systems. Insulation and current-carrying capacity are important factors.

Stranded wires, where joined, must be well twisted together and soldered. Good-quality insulating tape is applied over the joint.



By filing a groove in the nose of a soldering iron a better flow is obtained when dealing with twisted wire joints.



When joining twin wires care must be taken to see that they cannot touch each other. They must also be insulated from the armoured casing.

H.T. cables for the plug leads are usually insulated with pure vulcanized rubber and are either 7 mm. or 9 mm. in diameter. Sometimes a metal braided covering is used as an additional protection.

The main wiring should not be interfered with unless a definite fault is found or suspected, but connections, terminals and fuses should be inspected occasionally.

Sometimes several wires run in one direction, say from a fusebox to a distributor box at the rear of the car. The wires are braided together for convenience, and it may seem at first sight almost impossible to trace any desired wire from one end to the other. If examined closely, however, it will be seen that each one has a coloured thread or braiding inside its outer casing. If a wire with, say, green insulation (sometimes a combination of colours is used) is found at one end, then the other end of that wire is easily found by looking for the green insulation.

The wiring diagram of a car's electrical equipment usually marks these colours, so that any particular circuit can be found without disturbing the other wires.

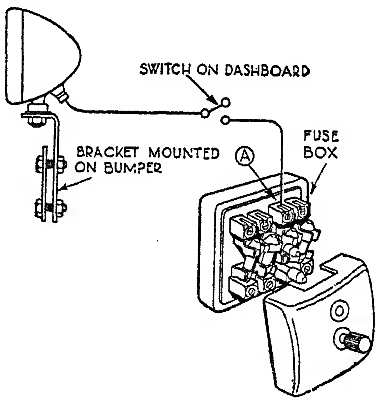
When making adjustments at a junction box, it is advisable to disconnect one lead from the battery or to use the battery master switch if one is fitted. This is necessary because where terminals are very close together a slip of the screwdriver may cause a short circuit, resulting in serious damage to components and the battery.

Other sources of short circuiting that should be watched very carefully are loose strands of wire.

Fitting an Additional Lamp.

An additional road or fog lamp can be fitted without difficulty to the front bumper. Unless supplied with the lamp the cable required will be armoured material of, say, 14/30 gauge. When ordering the necessary length of wire the bends and obstacles it must pass should be taken into account. Use a piece of cord for taking measurements, and remember that it is easier to cut off a piece than to make an electrically sound joint.

Before fixing the lamp to the bracket see that there is a good earth connection by scraping away any rust or enamel. Paint the edges well afterwards to prevent subsequent rusting. It may not, however, be desirable to damage the enamel or cellulose at this point of attachment, or a suitable earth may not be obtained, as, for example, where the bumpers are rubber-mounted. A second wire should then be taken from some part of the body of the lamp to a suitable point on the frame or engine. To attach the live wire to the lamp, bare the end by cutting away about 1 in. of the insulation. Take care not to cut through any of the wire strands, as this would reduce the carrying capacity of



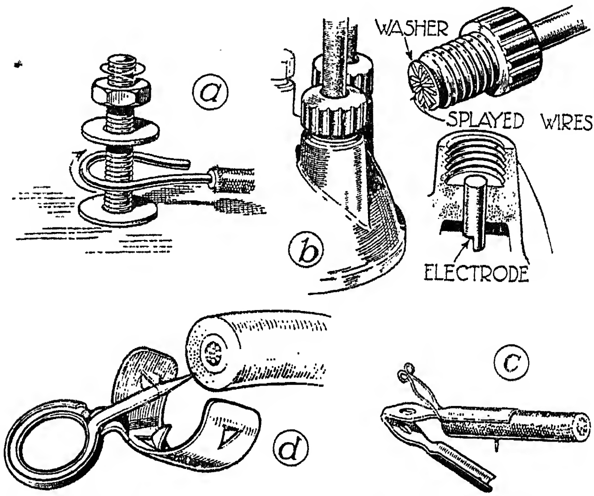
Fitting a fog lamp is not difficult: mount it on a bumper bracket which is more rigid than the bar itself and wire up as shown. Take the lead to the terminal marked "A" or "Aux" in the junction box.

the cable. The connection to the lamp is very often inside, and the wire is passed up through the securing support at the bottom.

If it is desired to connect the lamp up to the existing circuit through the fuse and ammeter (so that it registers when switched on), the wire should be taken first to one side of a switch, which can be mounted on the dashboard, and from the other side of the switch to the

terminal marked Aux (auxiliary) in the fusebox. If there is no terminal thus marked there may be a spare terminal in a junction box that can be used instead. Should it not be desired to connect up to, or interfere with, the existing wiring, the lamp cable may be taken through the switch and a fuse straight to the battery.

All cables must be secured so that they do not swing or chafe. New cables can be bound at intervals to existing wiring with insulating tape.



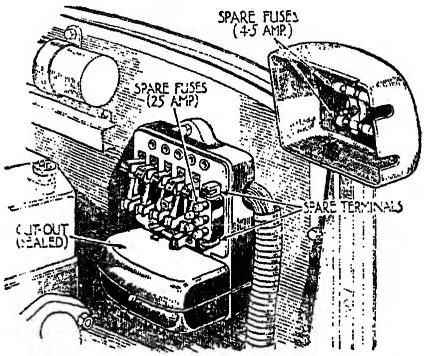
Electrical connections for car wiring. (a) Correct method of attaching wire to plain terminal. (b) Distributor head wiring. (c) Spiked split-sleeve for plug connection. (d) A prong-type connector that is easily fixed.

Connections.

When placing a wire under a terminal nut always twist the end so that, on tightening up, the wire does not tend to become untwisted. Leave about $\frac{1}{4}$ in. or $\frac{1}{2}$ in. of wire slightly slack; if, on tightening up, the nut takes up all the slack and strains on the wire, then vibration will soon cause a fracture.

When two wires are to be joined it does not constitute a good electrical contact merely to bare the ends and twist them together. This method serves as a temporary measure, but in time the wires may oxidize and thus cause a high resistance to be set up at the joint.

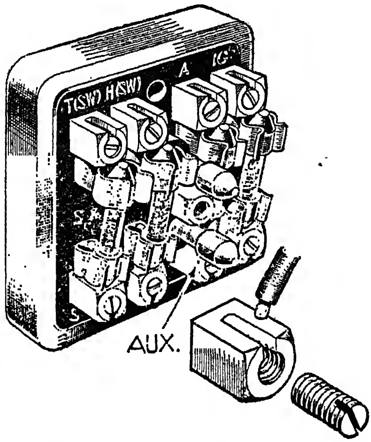
To ensure good electrical connections the wires should be carefully scraped, then twisted together, and finally soldered. The soldering flux used must be of



Protection for the electrical equipment against excessive overload is provided by fuses. The drawing shows a fuse box with the sealed cut-out below.

the non-acid variety or the joint may corrode. The convenient "Fluxite" soldering paste or powdered resin can be recommended. All traces of the flux must be cleaned away after soldering, and insulating tape should then be bound round the joint. Either the black, sticky type or the pure rubber tape can be used; the latter is tough and elastic, and can be wound tightly round the joint in several layers without very greatly increasing the diameter of the cable. Rubber tape is partly self-vulcanizing and does not tend to unwind, but a touch of rubber solution on the end makes it secure. Alternatively, the end can be secured by warming with a match, pressing it on to the layer of rubber beneath.

Connections to terminals which may be unscrewed occasionally are best made by soldering a suitable round or forked tag on to the end of the wire. A type of tag sometimes used for sparking plug terminal connections does not require soldering, a good connection being made by a projecting point that pierces the insulation and touches the wire. A similar method is used on some distributors for making contact with the H.T. wires.



In most fuse or junction boxes there is a terminal marked AUX, to which auxiliaries can be wired. The inset sketch shows details of the terminal.

Fuses.

Earlier in this chapter mention has been made of fitting a fuse in circuit with new accessories. Fuses are, of course, a necessary protection against overloading and are usually of the cartridge type, consisting of a small glass tube with a brass cap on each end. Soldered to the inside of the caps is a piece of fuse wire, the condition of which can be seen through the tubing. Inside the tube is also a strip of paper on which is marked the current-carrying capacity of the fuse. Various capacities are used for each particular circuit.

On modern cars it is usual to fit a fuse in each main circuit. The auxiliary circuit fuse has a margin allowing for extra accessories.

When a fuse blows it is an indication that something is wrong in that circuit, and no time should be lost in tracing the cause of the trouble. This may be a loose wire causing a temporary short circuit. In any event the cause of the failure must be ascertained. Never attempt to cure the trouble by fitting a fuse of larger capacity.

Tracing the seat of the trouble is not always easy, but if, for example, the head lamps go out suddenly immediately after being switched on it would be obvious that the trouble was in that circuit. By trying to operate each instrument in turn certain circuits can be verified as in order, leaving finally the defective circuit to be inspected.

Usually a spare fuse for each circuit is stored in a clip near the fuse box. A new fuse should be obtained to replace the used spare at the earliest opportunity.

Always be sure to use a fuse of the same capacity as the replacement.

If a proper replacement cannot be obtained in an emergency the ordinary fuse wire of the specified gauge can be used.

Should a 25-amp. fuse blow and the only available wire is of 5 amps., then five strands of this will serve if twisted together, but a proper replacement should be obtained at the first opportunity.

Expert advice should be sought in the event of persistent electrical failure.

Battery Master Switch.

These switches are fitted as standard on some cars, and their use is strongly recommended. A battery switch makes it possible to cut off the battery completely from all electrical equipment.

If the switch be situated in an inconspicuous position it prevents unauthorized use of the equipment and renders the car thiefproof.

CHAPTER V.

Coil Ignition.

COIL ignition provides an alternative to magneto ignition and offers a number of advantages.

The coil and distributor are much cheaper than a magneto, and they permit a far greater degree of ignition advance and retard. Compared with a magneto, the coil and distributor have fewer working parts.

The coil consists of a soft-iron core, the primary winding and the secondary winding. The iron core is not solid, but is composed of a bundle of soft-iron wires. This construction prevents the formation of eddy currents and does not tend to overheat, as would a solid core. Over this core, but insulated from it, is usually wound the primary winding. This consists of a few hundred turns of insulated copper wire, the resistance of which is usually about 1 ohm. Over the primary is wound the secondary winding, consisting of at least 16,000 turns of very fine copper wire about .004 in. diameter and generally enamel insulated. This has a resistance of up to 4,000 ohms. Layers of varnished silk separate the layers of wire, the whole sometimes being impregnated with paraffin wax.

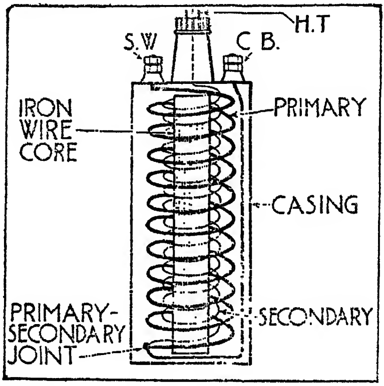
Some coils have the primary circuit wound outside the secondary, as this provides greater heat dissipation.

There are three connections on the coil, one from the ignition switch to the primary, one from the other end of the primary to the contact breaker, and one H.T. lead from the end of the secondary to the distributor. The other end of the secondary is connected to the primary and the circuit is completed through the ignition switch and battery to earth.

There are no moving parts in a coil, and the only attention necessary is to keep the connections tight and clean and the top of the coil free from oil and dirt.

Distributor Unit.

The distributor unit consists of three main parts, the contact breaker, condenser, and the H.T. distributor. The first two are in the L.T. circuit and the last in the H.T. circuit.



The windings in a coil are similar to those on the armature of a magneto. The condenser, an essential feature in the circuit, is usually incorporated with the contact breaker.

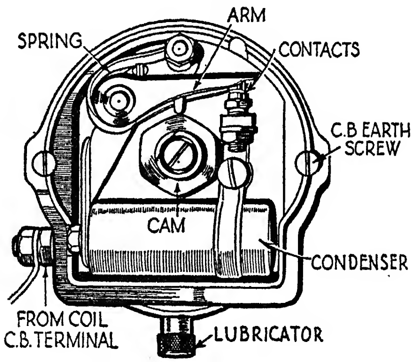
Contact Breaker.

The contact breaker consists of an arm pivoted at one end with one of the contact points at the other end. In the centre is a heel piece which bears up against a revolving cam. As the cam rotates the arm is pushed aside and the contact on the end is moved away from a second contact, on which it normally bears. In this way the primary circuit is broken as each lobe of the cam comes round, the arm being returned to the contact position by a spring. An accompanying illustration shows a typical contact-breaker unit with all the parts named. The contact points are usually of tungsten for coil-ignition sets.

Where coil ignition is used there is no maximum position of the armature to consider, as there is with a magneto. Full advantage has been taken of this fact, and there are several automatic advance and retard systems. Two automatic systems are sometimes used together or one automatic system with a hand control. Such control adds greatly to the flexibility of the engine and may be reckoned as one of the chief reasons for the popularity of coil ignition.

Condenser.

To assist in the efficient operation of the contact breaker and to prevent excessive sparking at the points, a condenser is connected across the contact points. A condenser consists of pieces of tinfoil separated by



Details of H.T. distributor.

sheets of mica or other insulating material. Alternate sheets of tinfoil are connected together, each set being insulated from the other, so that there is no electrical connection between the two sets of plates.

H.T. Distributor.

The H.T. current induced in the secondary winding of the coil is taken to the plugs through a rotor mounted on top of the contact-breaker cam. A connection from the H.T. lead of the coil is made by a carbon brush

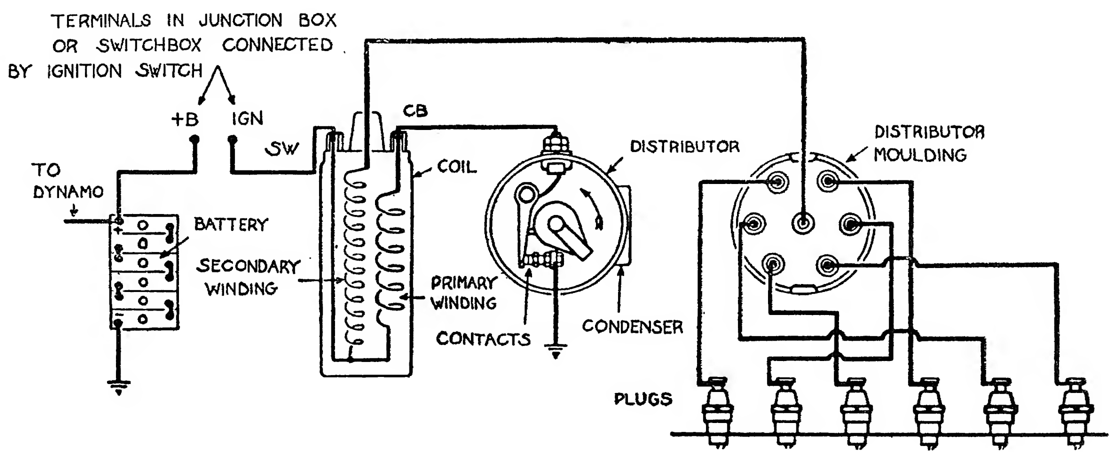
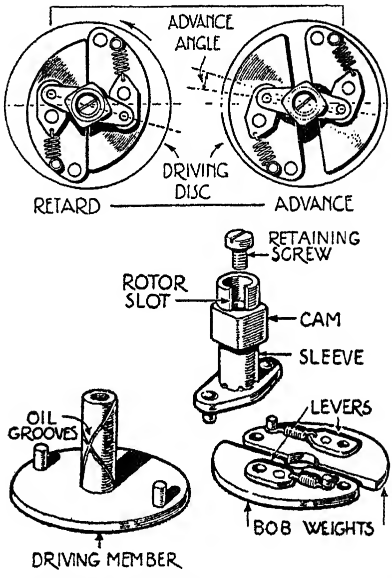


Diagram of the complete Lucas layout for the coil ignition system of a six cylinder car.

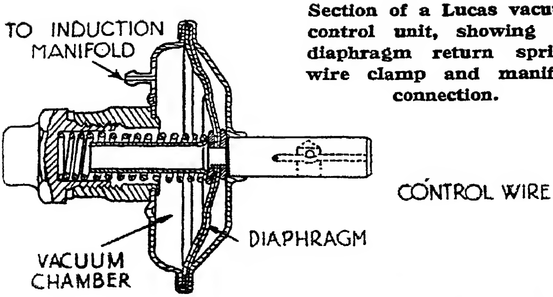
expert, some form of automatic control is necessary for general use.

Most modern distributors have some form of automatic ignition control. The two principal types are the centrifugal and the vacuum. Sometimes both types are used together or one may be used in conjunction with manual control.

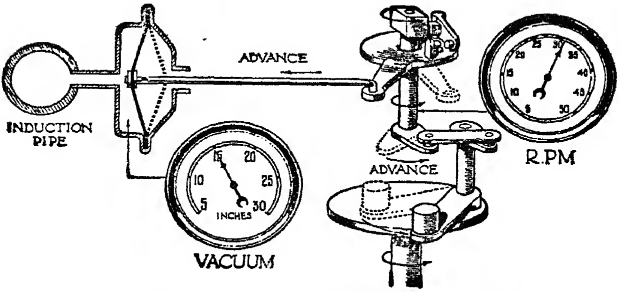


Working principles and details of automatic centrifugal ignition control. The bob weights fit over the pegs in the driving member disc, the cam sleeve fits over the disc spindle and its pegs engage with the levers.

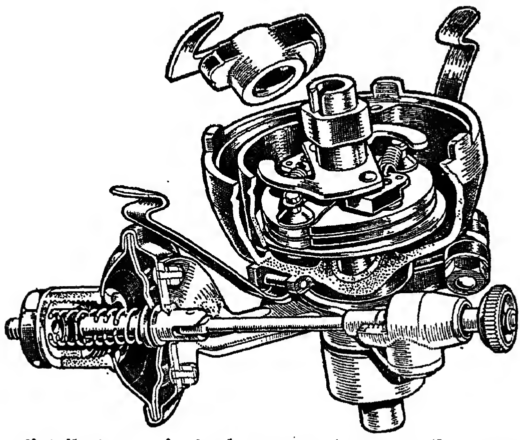
Centrifugal ignition control depends on the action of two rotating weights on the cam driving disc of the distributor unit, as indicated in the illustrations. When the speed of the engine increases the weights are flung outwards by centrifugal force. The links which transmit the drive from the driving disc to the cam are thus drawn inwards on their pivots and the cam is moved



Section of a Lucas vacuum control unit, showing the diaphragm return spring, wire clamp and manifold connection.



The relationship between centrifugal and vacuum ignition timing control is shown above. The dial readings are purely arbitrary relative to the control positions.



A distributor unit broken open to snow the centrifugal advance and retard and the vacuum control.

relatively in the direction of rotation. Consequently the contacts are broken sooner and the ignition is advanced. As the engine speed drops the cam is returned to its normal position by springs attached to the ends of the links. Vacuum ignition control makes use of the vacuum in the induction manifold, which is governed by the load on the engine. The control unit consists of a metal housing connected by a pipe to the induction manifold. In the housing is a diaphragm connected to the distributor head by a lever. The varying degrees of vacuum due to the engine suction flex the diaphragm and so alter the timing by turning the distributor head. It will be observed that the centrifugal system operates the cam whilst the vacuum diaphragm moves the distributor head. One system, therefore, does not affect the other, and when used together they give very accurate timing, as the ignition is then governed by the load as well as by the speed.

Micrometer Adjustment.

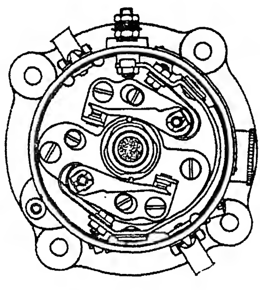
A fine adjustment is sometimes desirable to allow for variations in the condition of an engine. These circumstances may arise when the engine requires decarbonizing or when a change is made in the grade of fuel used, and special means of very fine adjustment are accordingly provided on certain distributors. By means of a knurled knob the distributor head may be turned very slightly so as to advance or retard the ignition. This is an easy means of adjustment which can be carried out in a few moments, either after or during a test run. A precise indication of the amount of advance or retard given can be seen from a scale on the head. One division on the scale is equal to two distributor degrees, and adjustments should not amount to more than one distributor degree at one time. Adjustments of this nature call for somewhat expert handling.

High-efficiency Engines.

Fine ignition timing is really only vitally necessary when applied to fast cars and high engine speeds.

There is no doubt, however, that it makes a big difference to ordinary cars, although seldom appreciated by the majority of drivers.

With high engine speeds, another point which has to be considered is that of the contact breaker. The period of "make" at the contact-breaker points is only one-sixth of an engine revolution, and with the engine running at 4,000 r.p.m. the "make" period is only 1/400 of a second. On account of the time constant any increase in speed will bring about a decrease in the intensity of the spark at the plug points, and may even cause misfiring. Consequently, when absolute efficiency is necessary, as in racing and in many six and eight-



For high-speed ignition. The Delco-Remy double-break distributor unit for a six-cylinder engine.

cylinder cars, double contact-breaker distributors are employed. A three-lobe cam is then used on six-cylinder cars and a four-lobe cam on eight-cylinder cars.

An alternative is provided by the use of two separate coils and distributor heads each serving half the number of cylinders. Another method employs a dual system incorporating a coil for starting and slow-speed running and a magneto for high speeds.

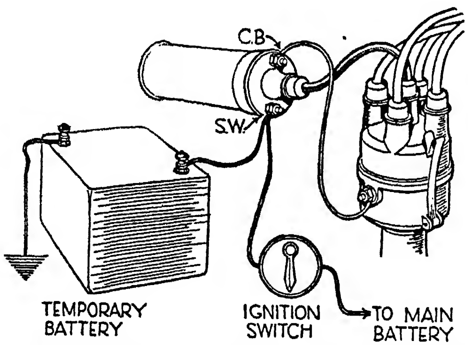
Some manufacturers now make a magneto coil-ignition set, which combines the best and most desirable features of both systems at less than the cost of two

separate installations. These sets are made so that they will replace existing coil distributor heads without any alteration in designs, and by the use of a switch mounted on the dashboard either system of ignition can be used at will. The same distributor, contact breaker and automatic timing mechanism are used for both the coil and the magneto circuits.

For modern high-speed engines using wider plug gaps and weaker carburetter settings for fuel economy, it has been necessary to produce a coil which, by using extra high voltage output will ensure complete and instantaneous combustion under these conditions. With these high-voltage coils satisfactory ignition can be obtained on engines running up to 10,000 r.p.m.

Safeguarding the Coil.

One thing which must always be remembered with coil ignition is that, if the engine be stopped and the



Coil ignition can be operated by using a temporary battery when the main battery is out of action.

ignition is left on with the contacts "making," there will be a continuous flow of current from the battery through the coil. The component would, therefore, heat up considerably and might eventually burn out, or at least melt the insulation, in addition to running down the battery. To guard against this, some coils

have a special nickel-alloy wire resistance fitted in the primary circuit. This wire passes the full current under normal conditions, but on heating up by uninterrupted discharge it increases its own resistance, so limiting the flow of current through the coil. Where the coil is not fitted with such a resistance, the circuit usually incorporates a warning light, which shows when the engine stops, or slows down below a predetermined speed, with the ignition switched on. The light thus gives warning that the battery is discharging through the coil.

Coil ignition will present a difficulty should the battery become so run down that it will not supply even the side lamps. Obviously there will be insufficient current to work the coil for ignition purposes. The engine can, however, be started without waiting for the battery to be charged from an outside source or exchanged for another battery. Another battery of small capacity is connected temporarily in parallel with the existing car battery. This will enable the engine to be started, and when running with the dynamo charging the temporary battery can be disconnected. In these circumstances the engine must, of course, be started by hand, as the small battery will not give sufficient output for the operation of the starter.

Contact-breaker Gap Setting.

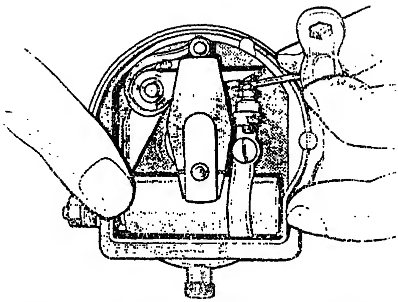
Exact setting of the contact-breaker gap is important, and as a rule a gauge is supplied with the car by which the correct gap may be set. The engine must first be turned by hand until one of the lobes of the cam has separated the points to their maximum extent.

In this position the gauge should just slide comfortably between the points; if there is considerable clearance, however, or, on the other hand, if there is not enough, the adjustment is made by first slacking the lock nut on the adjustable point, and then rotating this by its hexagon head until the gap setting is correct according to the gauge. The lock nut is then tightened.

When the adjustment has been made it may be found that owing to wear or burning the points do not come

squarely together. In these circumstances they must be trued by rubbing a thin strip of emery cloth between them or, preferably, by using one of the special carborundum slips which can be bought for the purpose. Having trued the points, a further check with the gauge should be made, because in all probability the gap will have increased; a further setting, therefore, must be made.

On some types of Lucas distributor and, in fact, on other makes also the contact-breaker adjustment is carried out by moving a plate, on which the points and rocker arm are mounted, relative to the cam. The screws carrying the plate are slackened and the plate



Setting the contact-breaker gap. The gauge should just slide between the contacts when they are fully separated by the cam.

moved bodily towards or away from the cam until the gap setting is correct, at which point the screws are again fully tightened. It will be clear, of course, that this adjustment is carried out with the points separated by one of the lobes of the cam, as in the previous case.

Checking Firing Order.

If the plug leads of an engine be detached and "mixed up" it will be necessary to trace the firing order when replacing them. Turn the engine by hand until the piston of No. 1 cylinder is at top dead centre on the firing stroke—as indicated by both valves being fully

closed. At that point the rotor in the distributor will be adjacent to one of the cover electrodes. Connect a plug lead from that terminal to No. 1 plug.

Again turn the engine and watch the valve movement. If it be a four-cylinder unit firing 1, 3, 4, 2, the valves of No. 3 cylinder will be the next to reach the "both closed" position. The rotor will have moved round to the next electrode. Connect its terminal with the H.T. lead to No. 3 cylinder. Having found the sequence of two cylinders, it then becomes only a matter of connecting the two remaining leads in the order of distributor rotation. The third electrode must belong to No. 4 cylinder and the fourth to No. 2.

On some four-cylinder engines the firing order is 1, 2, 4, 3, in which case positions 1 and 2 are traced by valve movement and the remaining two follow in sequence. Six-cylinder engines fire 1, 5, 3, 6, 2, 4 or 1, 4, 2, 6, 3, 5; again only two positions need be found for the others to follow according to the direction of rotation of the distributor rotor.

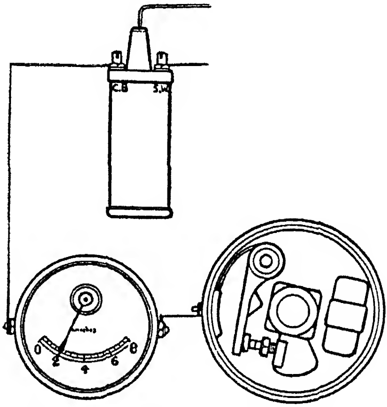
Resetting the Timing.

The actual timing of the ignition with Lucas, Delco-Remy and, in fact, practically all coil distributors is a simple matter. Assuming, for example, that the spark is to occur at t.d.c. with the control fully retarded, the process consists in turning the engine until the piston in No. 1 cylinder is at the precise top centre on the compression stroke.

The clamping bracket on the distributor body is then slacked; this allows the head to be rotated by hand. If the timing is merely being checked or slightly adjusted, it will be found upon removing the distributor cover that the rotor electrode is in a position adjacent to the terminal electrode of No. 1 cylinder plug. A lobe on the cam will be just bearing on the heel piece of the rocker arm and the points should be just separating. If they are fully open the timing is too far advanced for the required setting, and the distributor must be rotated forwards slightly, i.e., in the direction

of rotation of the cam. Move it backwards to advance.

As it is almost impossible to see precisely when the points open, a test lamp or an ammeter should be wired in the ignition circuit at the distributor "C.B." terminal. That is, the lamp or ammeter is put in series with the lead from the coil to the distributor. With the ignition switch "on" the lamp will light or the ammeter will show a reading so long as the points are closed. The



An ammeter, or a lamp bulb, wired in the circuit as shown, will aid accurate timing. The instant that the contacts separate the needle will drop to zero or the lamp will go out.

instant that they separate, however, the lamp will go out or the meter hand will drop back to zero. That is the moment of ignition.

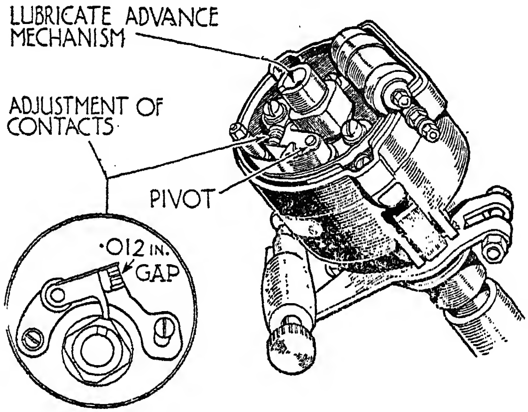
Maintenance.

The maintenance of coil-ignition equipment is a matter of great importance and pays for due attention.

The coil requires no special attention, but should be kept clean externally. All connections should be fully tightened. The coil should, of course, be mounted where it will not be subject to the heat from the exhaust manifold or engine or in too close proximity to the fan.

With regard to lubrication, the screw-down greaser on the distributor spindle should be given one turn every 500 miles; the grease used must be of good quality and have a high melting point. Where an oiler is provided instead of a greaser, one or two drops of thin machine oil every 1,000 miles or so will be all that is required.

The slightest smears of vaseline can be applied to the cam every 3,000 miles, and care must be taken to



Illustrating points mentioned in the text in relation to distributor lubrication and contact setting. A gauge must be used for measuring the gap.

see that no large quantity of lubricant is used within the distributor casing, as its presence on the contact-breaker points will give rise to trouble.

The automatic timing control is lubricated with thin machine oil. One must first pull off the rotor from the top of the cam spindle and then apply the oil around the edge of the screw, which will be seen recessed in the end of the spindle. The screw must not be undone: there is a clearance between it and the spindle for the oil to pass down to the timing control. This attention must be given about every 3,000 miles. The pivot pin on which the rocker arm of the contact breaker works

requires lubrication every 5,000 miles with just a single drop of thin machine oil.

If the distributor is mounted horizontally it will usually be found that the automatic timing mechanism is amply lubricated by oil, which finds its way along the spindle from the engine.

In the case of distributors mounted on the dynamo, the gear drive should be lubricated with high-melting-point grease, but only a very small amount is needed, as any excess may find its way either into the dynamo or into the distributor head, where it will cause trouble.

Cleaning.

With regard to cleaning, it is advisable occasionally to remove the distributor cover and to wipe the electrodes with a cloth moistened with petrol, at the same time taking care to remove any dust which may be present on the under face of the moulding. A certain amount of pitting of the faces of the electrodes is to be expected, but it will do no harm. When the distributor has been in use for a long time the edge of the rotor electrode will be found to be burnt away somewhat; the effect of this is to increase the gap between it and the electrode in the distributor cover. A small increase is of no importance, but when it becomes excessive it is advisable to renew the rotor. See that the central carbon brush is clean and moving freely in its holder against the pressure of the light spring, if the distributor be of that type. If it be of the metal-button type, make sure that the contacting faces of the buttons are clean and smooth.

The need for keeping the contact points free from grease or oil has already been mentioned, but if they are burnt or blackened they can be cleaned with a piece of very fine emery cloth and afterwards with a rag moistened with petrol. When in good condition the points should present a clean, greyish, frosty appearance. Excessive pitting or burning of the points is usually an indication that the condenser has broken down, in which case a new one must be fitted. This

can probably be done quite safely by an amateur mechanic if it be of the type held in place by screws. Where any doubt exists, however, regarding ability to do the job, it is always best to take the car to a service station.

Testing the Condenser.

Condenser faults may be due to a short circuit of the plates or a broken circuit between a terminal and its plates. To test for the first fault, the condenser should be connected in series with a lamp and the house lighting supply. If, on turning the switch, the lamp lights a short circuit is indicated in the condenser, which should be scrapped. Should the lamp fail to light, the condenser must be tested to ascertain whether it will hold a charge. For this test the condenser is connected to a D.C. supply, such as a wireless H.T. battery. One condenser terminal is connected to the H.T. positive and a lead from the other condenser terminal is applied momentarily to the H.T. negative.

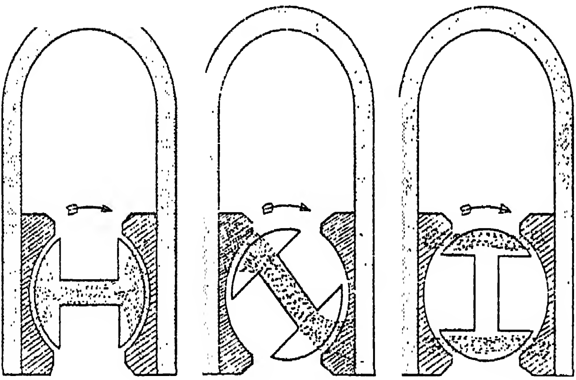
The condenser should now be charged and should indicate a discharge by sparking when leads from its two terminals are brought close together. If the condenser fails to charge and discharge in this manner it should be discarded. Insulated leads should be used for this test to avoid shocks.

CHAPTER VI.

Magnetos.

THE high-tension magneto has been developed into a very efficient instrument, and despite competition from coil ignition is still giving reliable service, especially where dual magneto coil ignition is used.

The magneto consists of an armature wound with two layers of wire termed, respectively, the primary and secondary windings. The armature is mounted between the poles of a steel permanent magnet, and on



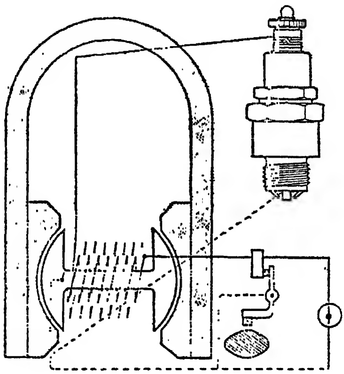
The rotating armature of a magneto affects the magnetic lines of force as indicated from left to right above. It is the distortion of the field which causes the primary current to be induced in the armature windings.

being rotated it generates a low-tension current in the primary winding. In two positions of the armature this L.T. current attains what is known as its "maximum flux" and the primary circuit is interrupted by the contact breaker. Breaking the L.T. circuit induces a

high voltage current in the secondary winding, which is taken through a slip-ring, brush and distributor to the plugs. The illustration on page 66 shows the two circuits diagrammatically.

The Armature.

The armature is built up of soft iron laminations, usually of H-section, and is mounted at each end in ball bearings. The primary winding comprises relatively few turns of fairly thick wire, and on top of this



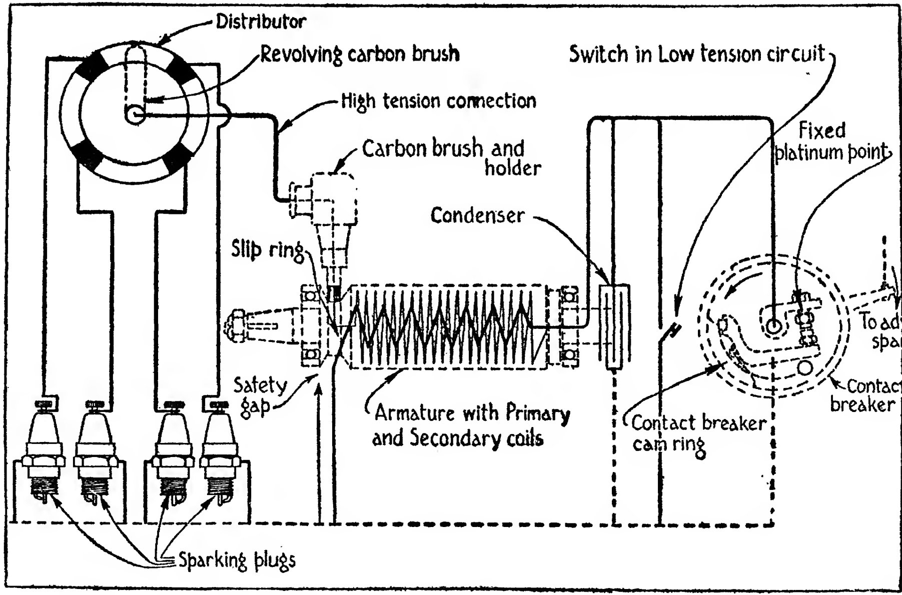
Armature windings and circuit of a normal magneto. The dotted lines indicate "earth."

is the secondary winding of many thousands of turns of very fine wire, about .004 in. thick.

One end of the armature spindle takes the drive from the engine, and on the other end is the contact breaker with a condenser mounted in a casing behind it.

The Primary Circuit.

One end of the primary winding is connected to earth and the other to the contact breaker. The connection to the contact breaker is made through the centre binding screw. The head of this screw fits into a recess in the metal block which carries one of the contact points.

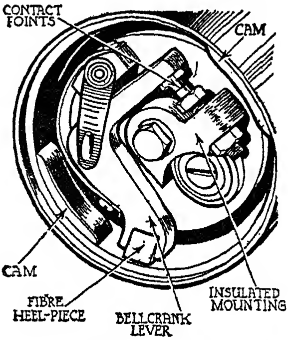


Complete circuit diagram of a four-cylinder magneto. The primary winding is that shown in heavy line.

This block is insulated from its mounting, so that the primary current can only flow when the contact points are closed. To ensure a good earth return, a brush attached to the back of the base on which the breaker unit is mounted bears against a contact ring on its adjacent bearing cover. This is necessary, as the only other return path available is through the bearings, which, being oily, are not good conductors.

Contact Breaker.

The contact breaker of a magneto consists of a rotating plate carrying a fixed contact point and a movable contact on the end of a bell-crank lever. The plate is attached to the armature and revolves with it.



A magneto-type contact breaker. The cams are mounted on a ring which can be moved within fixed limits to advance or retard the ignition.

Around the contact unit is a stationary cam ring. As the armature rotates one end of the bell-crank lever comes in contact with one of the cams on the ring, thus separating the contact points and breaking the primary circuit.

Secondary Winding.

One end of the secondary winding is connected to the primary winding, at a point where it joins the contact breaker and condenser. The path to earth of the

secondary current is consequently through the primary winding. The other end of the secondary winding is taken to a slip-ring on the armature spindle, and this ring is heavily insulated by ebonite flanges. Bearing on the slip-ring is a carbon brush, from which the H.T. current is taken to the distributor and thence to the sparking plugs.

Distributor.

The distributor is housed in an insulated casing around which are set four or six contacts, according to the number of cylinders. Current from the armature slip-ring is led to a carbon brush bearing on the distributor rotor. The rotor is fitted with an arm, driven by gears from the armature. Another brush at the end of the rotor arm passes the current to the contacts, from which it is taken to the plugs by heavy gauge cables. Sometimes, instead of using a carbon brush bearing against the contacts in the casing, a metal strip is mounted on the rotor, and this just clears the contacts by a few thousandths of an inch, the current jumping the gap. This is termed a jump spark distributor.

Safety Gap.

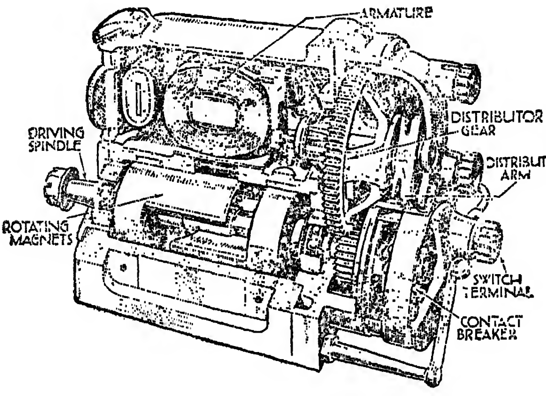
Should the resistance to the normal flow of H.T. current become too high for any reason, such as a broken connection, the armature windings would be subjected to a severe electrical strain and the insulation might break down. To guard against this contingency the magneto is fitted with a special spark gap that ensures safety by passing the H.T. current to earth.

Ignition Switch.

The magneto will continue to supply H.T. current to the plugs so long as the engine is running, and some means of stopping must be provided. This is done by shorting the primary current to earth before it gets to the contact breaker. Consequently there is no break in the primary winding and no current is induced in the secondary circuit to the plugs.

Polar Inductor Magnetos.

The normal type of magneto with revolving armature is quite satisfactory at comparatively low engine speed. As the speed increases, however, the windings become subject to a mechanical strain, due to the action of centrifugal force, which tends to tear them from the armature core. Another difficulty is that the revolving contact breaker must essentially be of somewhat limited size. This imposes restrictions upon its design, and



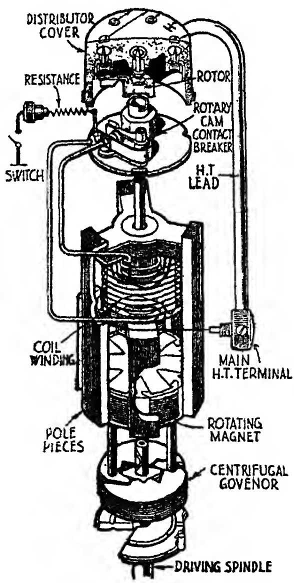
The B.T.H. polar inductor type of magneto in which the magnets revolve and the windings remain stationary.

centrifugal force tends to prevent precise opening and closing of the points. The disadvantages of the rotating armature type are overcome in the polar inductor magneto. In this magneto the windings are mounted on laminated poles above the main body, and two specially shaped inductors, riveted to a solid nickel steel shaft, form the rotor assembly. This rotor has, of course, greater mechanical strength than the ordinary wire-wound armature. Revolving between two cobalt steel magnetos, the rotor sets up a magnetic field which produces an alternating H.T. current in the primary windings. When this current reaches its maximum value the contact breaker opens the primary circuit

and so induces a H.T. current in the secondary coils. With this type of magneto the armature can be detached without the necessity for remagnetizing the instrument. This would only be necessary should the rotor be removed without taking special precautions to prevent demagnetizing. Briefly, such precautions comprise the placing of a steel "keeper" across the magnet poles.

Rotating Magnet Magneto.

This instrument is similar to the polar inductor magneto, but the reversal of the magnetic flux by the



A "skeleton" view of the Scintilla Vertex magneto, showing the arrangement of the various parts.

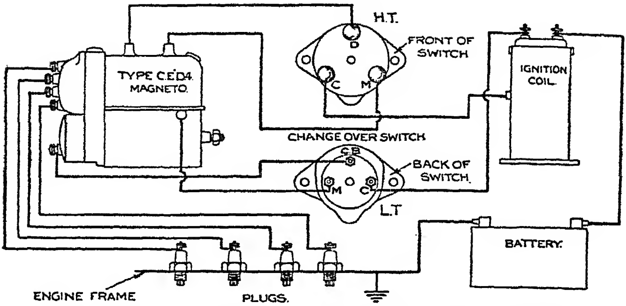
rotating magnets causes a L.T. current to flow in the primary winding. This L.T. current is broken by the contact breaker, operated by a small rotating cam attached to the end of the rotor spindle.

Coil Replacement Units.

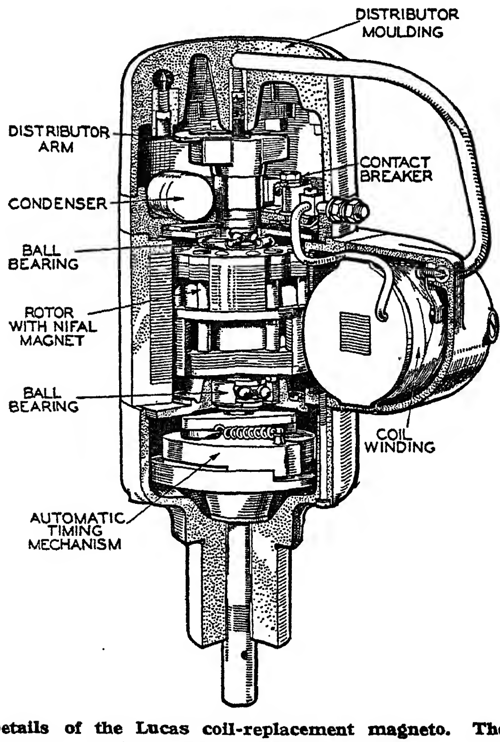
An interesting type of rotating magnet machine, introduced in recent years, has been designed to replace coil ignition on any engine without mechanical alteration. The instrument fits in place of the usual distributor unit assembly. Running at half engine speed the distributor is driven direct from the same shaft as the cam and magnets. A machine of this type is the Scintilla Vertex magneto, in which pole shoes of special formation are housed in a cylindrical moulded casing. The rotating magnet, made of cobalt steel, has several poles arranged alternately North and South. Beneath the magnet is an automatic advance mechanism. The stationary armature is mounted above the revolving magnet, whilst the contact breaker and distributor, on top of the instrument, are easily accessible by removing the distributor cover. The contact breaker is operated by a multi-lobed cam on the main driving spindle. A resistance is fitted between the switch and primary circuit to prevent the possibility of demagnetizing the magnets by accidentally passing a current through the windings.

In a similar coil replacement unit made by B.T.H. the armature windings are carried at the side of the main housing containing the rotating magnet and automatic timing device. By arranging the windings in this position the overall height of the instrument is conveniently limited, and the armature can be removed as a unit should repairs become necessary.

The Lucas coil replacement magneto incorporates a magnet made of "nifal," a special nickel aluminium iron alloy. The standard type of contacts are used, and the coil windings are carried at the side of the main casing. A special feature of the automatic timing control mechanism is the provision made for adding auxiliary weights, which, coupled to the main weights, give any desired timing curve. This magneto runs at half engine speed and works efficiently up to 10,000 (engine) r.p.m.



The B.T.H. dual-ignition system with earthed batterv.



Details of the Lucas coil-replacement magneto. The coil winding is a separate unit.

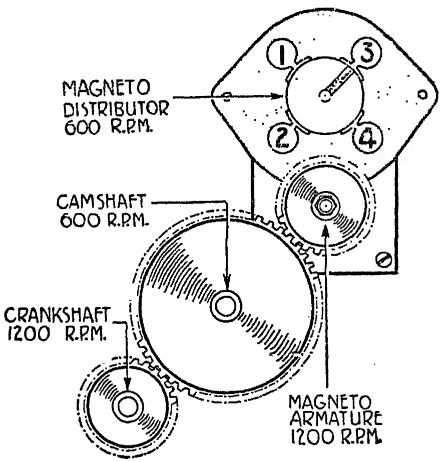
Dual Ignition.

Where high efficiency at all speeds is required dual ignition is sometimes employed.

With the polar inductor and the rotating magnet magnetos this is arranged by incorporating a coil and a special change-over switch, the contact breaker, distributor and automatic timing mechanism being common to both systems. All the desirable features of both methods are thus incorporated without the expense of two entirely separate ignition units. Dual ignition can be fitted to most cars. On those originally fitted with coil ignition it is necessary to exchange the distributor for a coil replacement magneto and add the change-over switch. On cars fitted with base-mounted magnetos of the polar inductor or rotating magnet type, an extra coil and change-over switch are necessary.

Magneto Speeds.

Coil replacement magnetos run at half engine speed, being driven by the normal distributor shaft. Magnetos



Gearing and timing of a four-cylinder magneto. The armature runs at crankshaft speed and the distributor at half speed. Note the 1, 3, 4, 2 firing order.

of the base-mounted type are run either clockwise or anti-clockwise. Speeds vary according to the drive from the engine and whether two or four sparks are produced per revolution.

Any of the following magneto speeds may be adopted:—

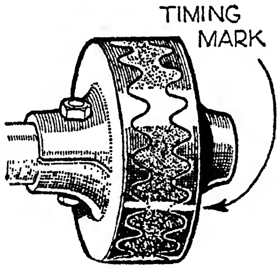
Magneto runs at engine speed (2 sparks per rev.) for 4 cylinders.

Magneto runs at $1\frac{1}{2}$ engine speed (2 sparks per rev.) for 6 cylinders.

Magneto runs at $\frac{3}{4}$ engine speed (4 sparks per rev.) for 6 cylinders.

Magneto runs at engine speed (4 sparks per rev.) for 8 cylinders.

The distributor must, of course, run at half engine speed, so that the gearing between the rotor and the distributor arm is either 2 to 1, 3 to 1, or 2 to 3. The

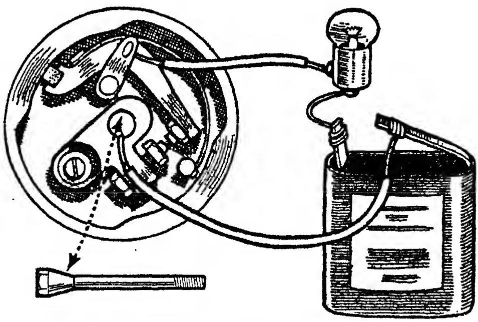


By marking the three parts of a Vernier coupling with a streak of paint correct reassembly is assured. A coupling of this kind allows a timing variation of less than one degree.

drive to the magneto is usually taken through a flexible coupling, such as a fabric disc, to allow for non-alignment of the armature and engine shafts and to allow for any sudden change in engine speed. In some cars a vernier coupling is used. This consists of two toothed flanges, one on the engine shaft and one on the magneto shaft, with a hard composition disc between them. One side of the disc is moulded to match the teeth on

the magneto shaft, and the other to match those on the engine shaft. The disc has 20 teeth on one side and 19 teeth on the other. Adjustment of the ignition timing is effected by loosening the driving flange and sliding it back out of mesh. The magneto spindle and composition coupling are then rotated the distance of one tooth in the direction required. Next the coupling is disengaged from the magneto flange and engaged with the driving flange. Finally the magneto spindle is rotated the distance of one tooth in the opposite direction to that previously taken. Because the two flanges have 19 and 20 teeth respectively one will have been turned forward 1/19 of a turn and the other will have been turned back 1/20 of a turn. Consequently the relative movement between the two shafts is 1/19 less 1/20 equals 1/380. of a revolution, which is less than one degree.

Some couplings incorporate an automatic advance mechanism working on the centrifugal principle.



By connecting a flashlamp bulb and battery as indicated exact timing is easy. The lamp will go out the instant the contacts are opened by the cam.

Timing.

Magneto timing, or the correct setting of the armature in relation to the engine crankshaft, is of the utmost importance, because the spark must be produced at precisely the right moment to ensure efficient running.

At low engine speeds sparking should occur just after the piston has passed top dead centre on the compression stroke, but at high and normal speeds the spark should jump the plug gap when the crankpin is between 20 degrees and 30 degrees below t.d.c. To retime a magneto after it has been disconnected from its drive, the engine should be turned until No. 1 piston is at t.d.c. on the compression stroke. The magneto armature should now be turned until the distributor arm is approximately opposite No. 1 lead contact. With the timing lever in the retard position turn the armature slightly until the points are just about to separate. The drive should then be connected up. This ensures correct timing for most modern engines, although if the manufacturers give a different setting in their instruction book their advice should be followed.

Maintenance.

The magneto is a precision instrument with which every care has been taken in manufacture. Accordingly, it should be treated with due care, and regular attention will ensure its reliability at all times. Three matters that should receive attention occasionally are: adjustment of the contact breaker points, lubrication, and the general cleaning and tightening up of connections and contacts.

The Contact Breaker.

This is designed to operate efficiently with a gap of a definite size when fully opened. The gap varies according to the design of the cam and the speed of the engine. As the contacts have to open and close some 12,000 times a minute on some engines, it will be appreciated that any increase in the gap will result in a much shorter period of "make" between the contacts. The usual gap for magnetos is .012 in. (12 thousandths of an inch), and this should be checked with a feeler gauge, the blades of which are usually marked in thousandths of an inch. The gap must be checked when the cam has fully opened the points, the gauge

just sliding between them. Unless the gap differs appreciably from the gauge it need not be adjusted. To set the points the lock nut on the adjustable screw should be slackened and the other nut turned until the gap is correct. The lock nut must then be tightened and the gap rechecked with the gauge. The points must be kept free from oil and dirt, and should meet squarely and make contact over the whole of their surfaces. A piece of cloth soaked in petrol passed to and fro between the contacts can be used to clean them.

If this treatment is insufficient the contacts should be rubbed with finest carborundum or emery cloth, afterwards washing with petrol, on a cloth or clean paint brush, to remove any particles that would prevent perfect contact. In some magnetos the contacts are of tungsten, a very hard metal which cannot be filed. When truing tungsten points it is necessary to use a carborundum slip (obtainable at most garages), and the work must be done before the gap is adjusted. To remove the contacts for inspection it is only necessary to undo the centre holding nut, when the whole unit may be withdrawn. The holding bolt forms the connection between the armature winding and the contacts. Care should be taken in replacing this, as the parts are specially shaped and only fit in one position.

Lubrication.

With regard to lubrication, only a few drops of thin oil are required for the armature spindle bearings every few thousand miles. As much harm can be done by over-oiling as by its neglect, and in some cases manufacturers do not make any provision for oiling, as the bearings are packed with grease during assembly and require no attention for many months. Oil that finds its way to the armature windings and contact breaker can cause a lot of trouble; oil on the contacts, for example, will oxidize the surfaces, setting up resistance which will greatly impair the efficiency of the instrument. By referring to the instruction book issued by the makers special points requiring attention will be

found. With coil replacement magnetos the automatic timing mechanism should not be forgotten. The fibre bush on which the rocker arm pivots must work freely; should it exhibit any tendency to stick, the arm should be removed and the pivot rubbed lightly with a piece of sandpaper and carefully cleaned. If the bush be rubbed with a "lead" pencil before replacing the graphite will act as a lubricant.

Carbon Brushes.

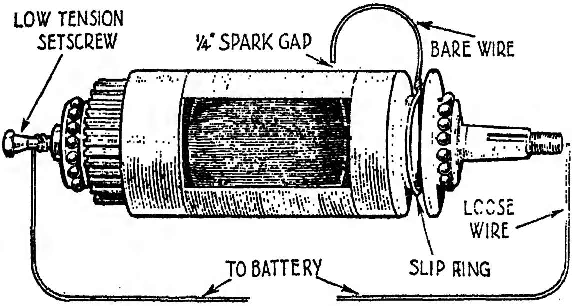
The carbon brushes used in magnetos wear after a time and leave behind a certain amount of carbon dust. It is quite possible for current to leak across the surface of this dust, and with the distributor brush this would lead to misfiring. Contact surfaces should, therefore, be wiped with a petrol-damped cloth to remove dust. When in good condition the working faces of all brushes should have a polished appearance, showing that it is making contact over the whole working area. The carbon brush in the distributor cover, which makes contact to the revolving distributor arm, must be free in its guide. The segments in the distributor cover may be cleaned with metal polish if necessary, or if badly worn or pitted they should be taken to a garage to be trued up by turning or grinding.

Armature Removal Precautions.

If the armature is to be removed care must be taken first of all to see that the teeth of the distributor gears are marked for correct remeshing. The contact breaker and the high-tension collector brush must be removed before sliding out the armature. It is generally more convenient to remove the armature from the driving end of the machine, as it is not then necessary to take off the coupling, which is a tight fit on the tapered end of the armature spindle. The instant that the armature is withdrawn from its tunnel a keeper must be slipped across the magnet pole shoes, otherwise there will be a loss of magnetism. The keeper must remain in position so long as the armature is out of the tunnel. Any

fairly heavy piece of iron or steel will serve as a keeper, but it should have flat faces, so as to make proper contact with the magnet poles.

An armature must never be washed in petrol because of the risk of dissolving the insulating varnish. Careful wiping with a rag should be all that is necessary, but if there is rust on the laminations this can be removed by gently rubbing with glasspaper. Rust sometimes forms, owing to the presence of moisture, in the armature tunnel. As the clearance between the



A simple armature test. With a battery in circuit a spark should jump the gap when the loose wire is "flicked" against the end of the spindle.

armature and the pole shoes is only a few thousandths of an inch this rust may prove harmful and should be removed. When refitting the armature great care must be taken to see that the bearings are properly in place.

Remagnetizing.

After many years' service a magneto may be found to be giving only a weak spark; this can often be traced to a loss of magnetism in the permanent magnets. The trouble may develop if the instrument has at any time received a sudden blow or has been working under very hot conditions. The original full strength of the magneto can be regained by remagnetizing. Special plant for this work is available at most service stations.

CHAPTER VII.

Sparking Plugs.

SPARKING-PLUG design has been brought to a high standard of efficiency, despite difficulties imposed by increasing engine pressures and speeds and high internal temperatures.

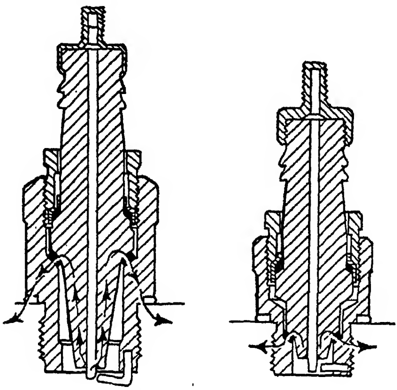
The modern plug consists of two main parts, a steel body which is screwed into the cylinder and an insulated centre piece through which passes the electrode. The insulation can be of mica, porcelain, steatite or other heat-resisting material of the requisite mechanical strength. The tip of the central electrode is brought to within 15-20 thousandths of an inch of an earthed electrode at the end of the body in the cylinder, and it is across this gap that the current has to jump in the form of a spark.

In the open air the passing of a spark across the gap would be a simple matter, but this has to take place inside the cylinder with its charge of highly compressed gases. The compressed mixture offers considerable resistance to the passage of a spark. In addition, when the charge has been fired the point of the plug reaches a temperature of about 400 degrees C.

Heat is the plug's greatest enemy and, therefore, it must have good heat-resisting properties. The plug must also be designed so that the heat is conducted away to the cylinder-cooling water as quickly as possible. Otherwise there would be a risk that the point of the plug (the hottest part) would become sufficiently hot to fire the next incoming charge at the wrong moment, so causing pre-ignition. Nearly all the heat has to pass up the central electrode and thence through

the insulation and seat gasket to the body of the plug and the cylinder head. Very little heat is transmitted through the threaded portion of the plug in the cylinder head, and sometimes cooling fins are added to the plug terminal to assist heat transfer from the central electrode.

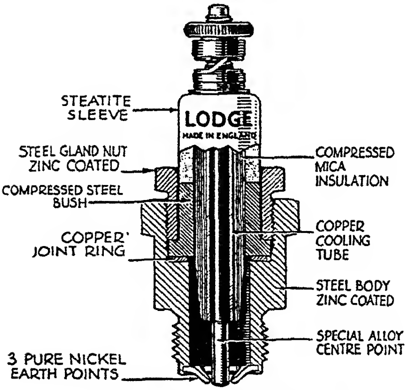
Great heat impairs the properties of the insulating material, which must be, therefore, of the finest quality or H.T. current will leak through or across the insulation. Any fault in the insulation results in weak sparks or in complete ignition failure. It will be seen, there-



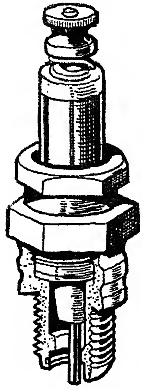
Heat paths from plug points are shown by the arrows. The plug on the left is suitable for a cool engine, that on the right is modified for high speed work.

fore, that although the sparking plug has a simple duty to perform it has to work under very unfavourable conditions. It has to fire under the compression of the mixture, it must be gas-tight, the insulation must be very good and the heat-resisting and conducting properties must be of a high standard. Manufacturers have spent a considerable amount of time and money on research work to produce the modern sparking plug, which has to stand up to all the foregoing conditions. There should be no difficulty in finding the right plug

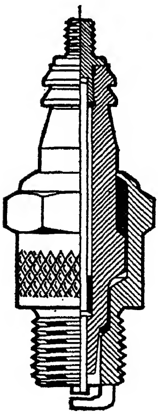
SPARKING PLUG TYPES



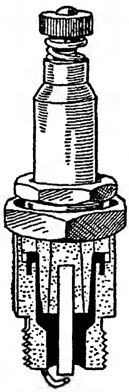
Section of the Lodge plug.



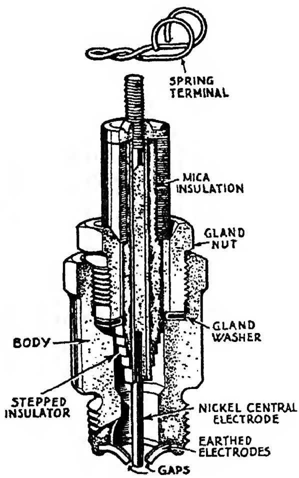
The E.R. plug with copper-plated central electrode and special alloy points.



A Champion non-detachable plug with Sillment sealing and Sillimanite insulator.



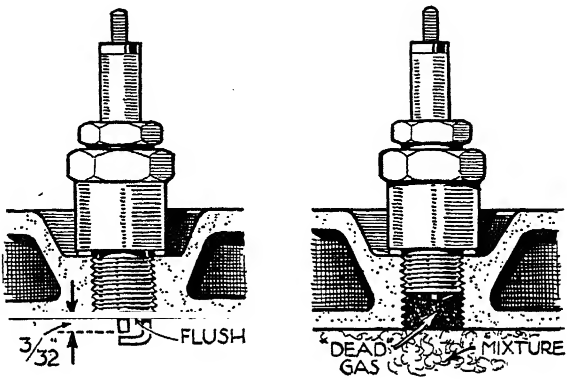
Hobson Nonoil plug with ante-chamber round insulator to obviate fouling by burnt oil.



The K.L.G. plug.

for any car, as nearly all makers have charts showing the plugs best suited for various engines. Little can be gained by trying plugs other than those recommended by the makers. Racing plugs, for instance, will not add speed to the engine of the family saloon; similarly, an ordinary plug will probably burn out very quickly in a racing engine.

The two types of plug in general use are the 18 mm. and 14 mm. Either of these may be of the long-reach or short-reach type with the threaded portion $\frac{3}{4}$ in. long or $\frac{1}{2}$ in., according to the design of the engine in which

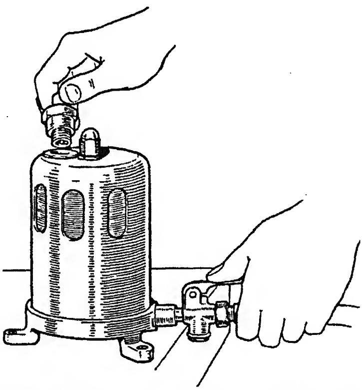


Correct plug fitting (left) is important. The right-hand plug is badly "pocketed" and operates inefficiently in a "dead" area.

it is to be used. Some plugs have one point and others two or three. The 14 mm. plug, previously used in aero engines, was originally introduced to assist designers of o.h.v. engines of special design where there was not room for the normal 18 mm. type. A type of plug used mainly in American engines is similar in general construction to the foregoing, but has a $\frac{7}{8}$-in. special taper thread which tightens with a jamming action in the cylinder head.

The general construction of plugs is shown in the

illustrations on page 82, and the majority are of the type that can be dismantled for cleaning. The cleaning process is necessary because after a certain period of use carbon forms on the insulation and reduces the efficiency of the plug. Current readily escapes across the carbonized surface and causes misfiring. Sometimes carbon may even bridge the gap at the points. Multi-point plugs do not overcome this difficulty because electricity always takes the path of least resistance, which would be across the carbon. The purpose of using multi-point plugs is that, when one point gets burnt away by continual sparking and the gap becomes too wide, the spark jumps from one of the other points the gap of which is still set at the correct distance.



The B.E.N. plug cleaner for service station use. It is worked by compressed air.

Plug Cleaning.

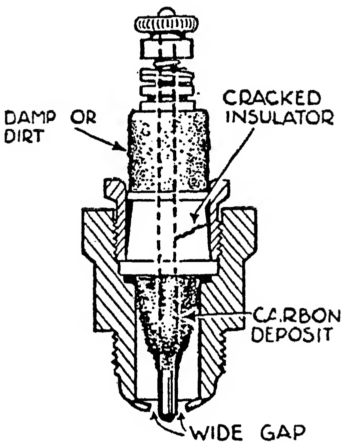
If of the detachable type, it is a simple matter to clean off the carbon which collects on the insulation inside the plug. After undoing the gland nut and with-drawing the centre portion the insulation should be wiped with a rag damped with petrol, which should clean off nearly all the carbon. Alternatively, it may be necessary to scrape off the carbon, taking great care

not to damage the mica insulation. The metal body can be cleaned by scraping off the carbon from the inside with a penknife or other form of scraper and a wire brush may be used on the points. The central electrode should not need scraping, but may be cleaned gently with fine emery cloth. When reassembling, all parts should be cleaned carefully and wiped with a rag damped with petrol.

Plug Faults.

When misfiring does occur and the plugs are suspected, the trouble is probably due to one of the following causes:—

1. Points too wide apart.
2. Cracked or damaged insulation.
3. Layer of carbon on insulation or points.

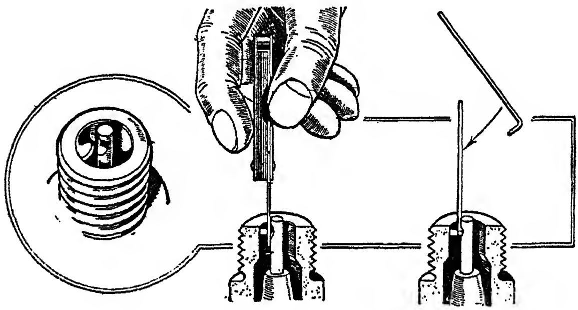


Causes of plug failure. Any of the faults indicated may give rise to misfiring or complete breakdown.

To determine which plug is at fault without removing them all, start the engine and let it run slowly. Then, with the end of a wooden-handled screwdriver placed in good contact with the cylinder head, touch the

terminal of the plug with the upper part of the metal blade. If this action affects the running of the engine it indicates the shorting of a good plug. Try each of the plugs in turn, and the one on which the screwdriver does not affect the running of the engine is the faulty plug.

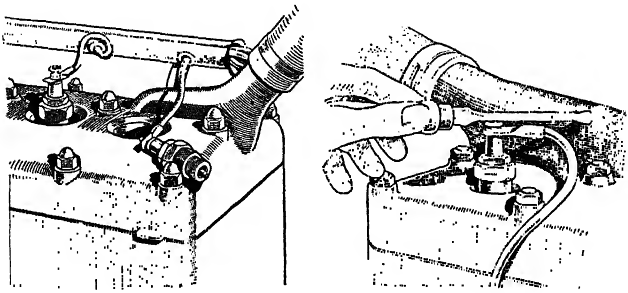
Then it is advisable to ascertain whether H.T. current is reaching the plug terminal. To do this, place a screwdriver as before, with the point making contact with the cylinder head, but do not actually touch the terminal with the blade; leave a gap of, say, $\frac{1}{16}$ in. Should a spark appear at the gap, it shows that current



A badly pitted or burnt electrode (extreme left) will not give a correct gap reading with a feeler gauge (centre). It is then preferable to use a round wire (right) of known diameter as a gauge.

is duly reaching the plug and no suspicion rests on the H.T. leads. Next, the faulty plug may be taken out and given another test by resting it on the cylinder head with the body making a good earth contact. With the cable reconnected to the terminal and the ignition switched on, watch the points while the engine is turned by hand. A spark should appear at alternative revolutions of the crankshaft, although this does not necessarily mean that it will fire when in the cylinder. The test does indicate, however, that the plug requires cleaning or adjustment of the gap, hence its failure to

function under compression. The gap may be adjusted with a pair of pointed nose pliers by gently bending the point on the shell inwards. This is best done after the central insulated part has been detached, so saving the possibility of damage to the central electrode, at the same time facilitating the cleaning of the insulation. The points should be checked with a gauge, as it is not



Testing plug (left) by placing on cylinder head and (right) by earthing with a screwdriver.

possible to guess the amount of gap accurately. The usual gap is .020 in. (20 thousandths of an inch), but there is no set rule, and some makers use a gap of 28-30 thousandths. Correct settings are usually to be found in the makers' instruction books, whilst some manufacturers issue free gauges for use with their plugs.

Most garages will, if required, undertake plug cleaning and adjusting at a small charge.

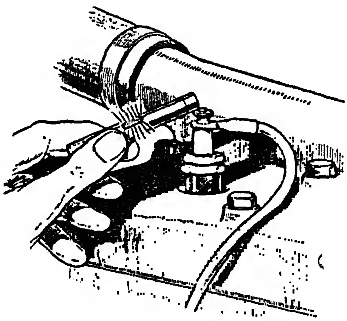
Faults in H.T. Leads.

When tests, carried out in the manner previously described, reveal that H.T. current is not reaching any plug, then the cause must be sought in the H.T. leads. The H.T. cable to the plug may have been rubbing against part of the engine or chassis, and if the cable cover is cracked or perished the current will leak away to earth instead of going to the plug. The trouble is remedied by fitting a new cable. If the leads are in order, then inspect the distributor or magneto.

Neon-tube Testers.

A very good idea of how a plug is behaving in the cylinder can be gained by the use of a neon tester. This consists of an insulated holder in which is inserted a sealed glass tube containing neon gas. The tube is connected at one end to a piece of metal, which may take the form of a cap on the end of the insulated holder.

In use the tester is brought against each plug in turn,



A neon plug tester in use. It is held to the plug or cable and indicates passage of the H.T. current by emitting a glow of light.

so that the metal part touches the plug terminal. The test is made, of course, with the engine running, and if a plug is sparking properly there will be a series of bright flashes in the neon tube, whilst faulty sparking is indicated by the dullness or irregularity of the flashes.

A neon tester is useful also in tracing leakage of high-tension current along the cables connecting the plugs to the distributor. The tube will glow when brought near the cables, even when the insulation is perfectly good, but if the rubber be cracked or perished the glow at that point will be very much brighter.

CHAPTER VIII.

Starters.

THE convenience of a mechanical device that would start the engine without recourse to turning by hand was recognized in the early days of motoring. Considerable research was devoted to the problem with the result that we now have a number of thoroughly reliable devices, electrically operated, for starting up.

The most common type of starter now in use comprises an electric motor, on the spindle of which is a pinion that engages with teeth on the rim of the engine flywheel. The starter is usually mounted on the side of the engine casing, at the rear, with the armature spindle extended towards the flywheel.

The starter is very similar to a dynamo in its general construction in that it has field windings, an armature, a commutator and brushes. There is a difference, however, in the windings, as the fields are connected in series with the armature instead of being in shunt, as in a dynamo. Usually there are four brushes, two positive and two negative.

The field windings are of heavy-gauge copper wire, or sometimes copper tape, whilst similar heavy wire is used on the armature. This is necessary because of the high-amperage current which passes through the windings, particularly at the instant of closing the starter switch.

A series-wound motor has the property of exerting its maximum turning effort when starting from rest, and this is just what is required when a stiff or sluggish engine has to be rotated. As the speed of the motor rises its torque or turning effort is reduced, with

corresponding reduction in current demand; thus, whereas at the instant of closing the switch there may be a drain on the battery to the extent of, perhaps, 200 amps., the current will drop to, say, 30 amps. within one second and the starter will continue to rotate the engine at a speed which depends upon the bearing stiffness, oil viscosity, and so on.

If the starter pinion engages with the flywheel, but does not rotate the engine, the battery will be almost dead short-circuited, and the starter button should be released immediately. When the starter switch is closed the rush of current from the battery to the motor causes an appreciable voltage drop, a normal 12-volt battery showing, perhaps, only 9 volts at the instant of discharge.

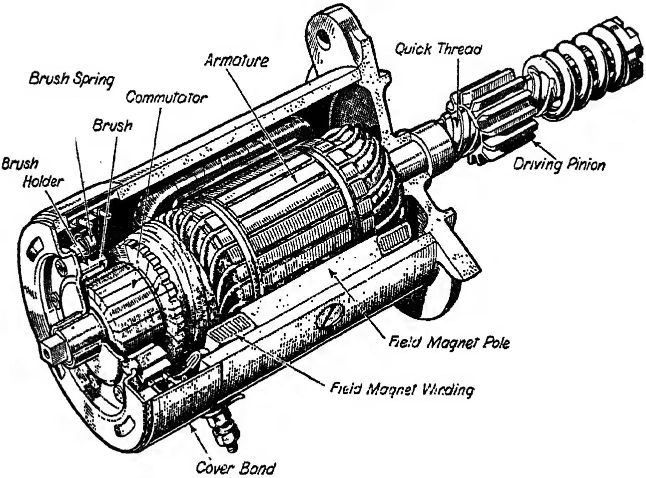
Starter Cables.

If is of great importance to avoid reduction in voltage as much as possible, and for this reason heavy cables and connections are used between the battery and the starter. Ample size wiring is necessary also to avoid overheating; and, incidentally, because so large an amount of current has to be dealt with the ammeter is not connected in the starting circuit, as a very heavy type of meter would be necessary to carry the 200 amps. or so that may pass. Although the demand made upon the battery is so very high at the moment of closing the starter switch, the actual current consumption is not really great. Assuming, for instance, a battery of 60 amp.-hr. capacity, charged normally at 8 amps., the current used in making one start would be replaced in about half a minute.

The energy consumption depends, of course, upon the stiffness of the engine, and it can be shown that 40 per cent. or more current will be needed to start an engine from cold than when it has reached a running temperature of, say, 85 degrees C.; similarly, the speed at which the engine is rotated by the starter when hot may be 50 per cent. or so higher than when cold.

Easing the Starter Load.

It will be appreciated, therefore, that every effort should always be made to use the starter sparingly. This does not mean that the engine should be cranked by hand every time, as starting systems are designed for use under all conditions, and if the battery, starter and engine are in proper working order there should be no need to crank by hand. Should the driver, however,



The principles of construction of a typical starter (Lucas).

care to turn the engine over half a dozen times on a cold morning before using the starter, the battery obviously will be assisted. Also, by seeing that the mixture and ignition controls are correctly set, unnecessary use of the starter can be avoided.

If the engine does not fire within a second or two of pressing the starter button it should be released. Never keep the starter turning the engine over for long periods, for by releasing the button and waiting a few seconds before trying again the battery is given a chance to recover its voltage. At the same time, the mixture drawn into the cylinders will be given a chance to

vaporize under the effect of the slight warmth caused by the compression of the charges, even although they may not have fired. Naturally, conditions can arise with which the starter and battery are definitely unable to cope, an instance being in extremely cold weather, when thick or gummy oil is used in an engine having rather tight bearings or closely fitting pistons.

Considerable harm can be done to the battery and starter if the current be allowed to flow continually with the engine only just turning over.

Thus, if the battery is not capable of turning the engine over fairly quickly the starting handle must be used, either alone or in conjunction with the starter, in which event, of course, an assistant will be necessary to press the button or crank the engine. To assist further, the person in the driver's seat who is to press the starter button should also hold the clutch pedal out of engagement. This cuts out the resistance of the gears in the gearbox, which usually revolve in thick, heavy oil.

Power Output.

From the actual power-output point of view, there is not much to choose between 6-volt and 12-volt systems as applied to starting, but the amperage at 6 volts will be double that at 12 volts; therefore, other things being equal, the former should have double the ampere-hour capacity, the cables must be heavier and the brushes very carefully designed owing to the heavy current which they must pass without causing any considerable voltage drop. It will be clear that a reduction of one volt in a 6-volt system is greater proportionately than it would be in a 12-volt system.

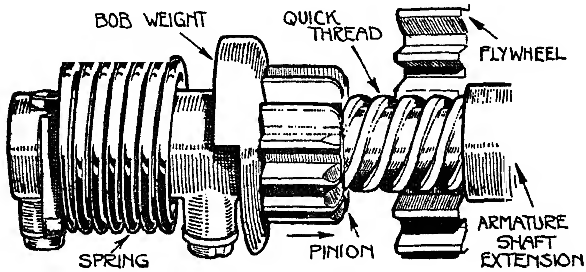
Manufacturers have, however, dealt very satisfactorily with the brush problem, and by using special grades of carbon they can ensure only a minimum voltage drop with either 6-volt or 12-volt equipment.

When fitting new brushes, therefore, it is important to use only the type recommended by the makers. To the uninitiated all brushes may look alike, but there can

be very considerable differences in the materials of which they are made.

Starter Maintenance.

The method of cleaning the commutator and bedding-in the brushes are exactly similar to those described for dynamos, although with starters it is even more important that the brushes be bedded very carefully to the commutator and the brush springs properly set. As a rule the springs exert rather greater pressure



The Bendix starter drive has an out-of-balance pinion to ensure rapid engagement; the drive is transmitted through, and cushioned by, the spring.

than in a dynamo, and as the starter may get very hot in use there is a chance that the brush springs may lose their temper. Weak springs should be replaced, as they cause bad contact between brushes and the commutator, resulting in lack of power from the starter. When set properly the brushes should last for some thousands of starts.

The Bendix Drive.

The normal type of starter motor rotates the engine through the medium of a pinion engaging with a toothed ring on the flywheel. The motor spindle is extended beyond the casing and carries a sleeve in which is cut a coarse-pitch thread. The pinion is screwed to suit the thread and the sleeve is connected to the motor spindle by a stiff helical spring, the whole assembly

being called, after its inventor, the Bendix drive. As a rule the pinion has a small bob-weight formed upon it, so that it is slightly out of balance.

The motor is mounted close to the flywheel, so that the pinion, when at rest, is in line with the toothed ring on the flywheel. When the starter button is pressed the armature instantly rotates at a very high speed, but the small pinion, being slightly out of balance, does not at once rotate with it; instead, it lags behind momentarily and is moved axially along the quick-thread towards the flywheel ring, with which it then engages, the spring drive relieving the shock of the engagement. So soon as the pinion is fully home it rotates the flywheel until the engine starts or the starter circuit is opened. In either case the pinion is automatically disengaged.

The pinion must move with perfect freedom on its thread, as any sticking may result in its not being moved into engagement with the flywheel ring. That this is happening is always indicated clearly by the high-pitched hum of the motor and the absence of the familiar noise made when the pinion engages. As a rule it is necessary only to clean the thread with petrol or paraffin to free the pinion, but on most makes of car this involves removing the motor from the engine.

After cleaning, the thread should not be oiled, as it is intended to work dry; sometimes, however, a suspicion of graphited penetrating oil or some other equally thin lubricant may be beneficial.

Very occasionally trouble is caused by breakage of the Bendix-drive spring, when, of course, a new one must be fitted. The springs are made in various types, so that when ordering a spare it is advisable to send the old spring as a pattern.

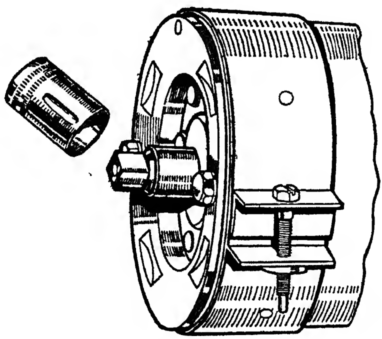
Freeing a Stuck Pinion.

It is by no means unknown for the pinion to jam in engagement should the engine fail to start. When this happens the usual method of freeing the pinion is to engage a gear and rock the car backwards and forwards.

The irregular movement thus imparted to the flywheel should cause the pinion to move back out of mesh.

Modern starters often have the armature shaft extended at the brush-gear end, so that it projects an inch or so. The projecting portion is of square section and thus may be engaged by a spanner and turned a little when the pinion jams. This is a very effective method of freeing it. The squared end is sometimes protected by a spring-on metal cover.

On the majority of Lucas starters the Bendix drive is not used; instead the screwed sleeve is slidably mounted



Lucas starters have a square-ended armature shaft, covered by a cap. Should the drive jam in engagement it may be freed by turning the shaft with a spanner.

on splines cut in the armature shaft. This extends beyond the end of the sleeve and on the extension is mounted a strong helical spring; a nut on the end of the shaft compresses the spring against the sleeve.

The pinion, which has no bob-weight, moves freely on the quick-thread and in its fully home driving position comes against an abutment on the shaft.

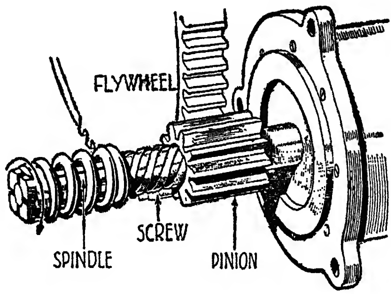
Cushioning the Drive.

It will be clear, however, that as the teeth come into mesh the resistance to rotation imposed upon the pinion will set up a reaction which causes the sleeve to move axially so that it compresses the spring.

In this way a cushioning effect is provided; furthermore, if the teeth of the pinion and flywheel ring are not exactly in a meshing position the "give" of the spring prevents damage being done to the edges of the teeth. As the spring does not carry the full driving load, however, breakage is most unlikely.

In the latest drives of this kind a clip is provided to hold the pinion in its free position. This avoids all risk of its moving along the thread and coming into occasional contact with the rotating flywheel. The pinion disengages instantly from the clip when the starter circuit is closed.

There are certain types of starter in which the pinion may be engaged by axial movement of the armature



In the Lucas drive a threaded sleeve slides on the splined armature shaft and is cushioned by a spring.

so that the teeth come into mesh without shock. So soon as they are fully engaged rotation takes place in the ordinary way.

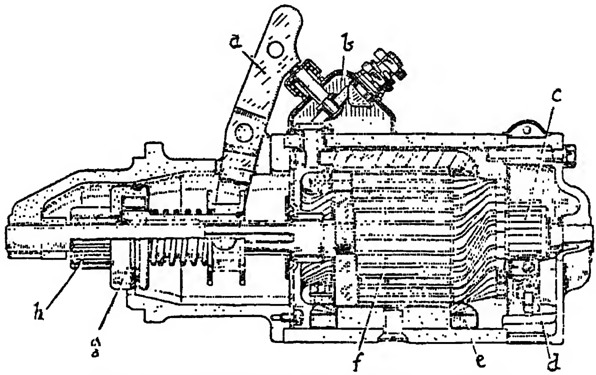
In one system of this kind the pinion is moved into mesh by means of linked levers coupled to a pedal on the floorboard. Inter-connected with the levers is an arrangement whereby the brushes are lifted from the commutator, thereby dispensing with a switch. The action of depressing the pedal first moves the pinion into engagement and then lowers the brushes on to the commutator so that the motor starts. When the engine

fires a free wheel in the motor gearing comes into action and continues to operate until the pedal is released, thus withdrawing the pinion and lifting the brushes.

Dynamotors.

Another method of engine starting is by means of a dynamotor, which, as its name implies, is both a dynamo and a motor. The machine is coupled directly to the engine through the medium of a chain or by gearing. It is specially wound and may have two commutators and two sets of brushes, but as a rule the normal single-commutator third-brush system, as in a dynamo, is adopted. The two main brushes are of heavy section to carry the starter current easily.

One of the troubles which has to be overcome with



The Bosch starter which is operated by a pedal.

a dynamotor is that of choosing the correct gear ratio. To obtain sufficient torque for starting, when the machine is used as a motor, the gear ratio should, of course, be very low, but this would mean that when working as a dynamo the ratio might be too high.

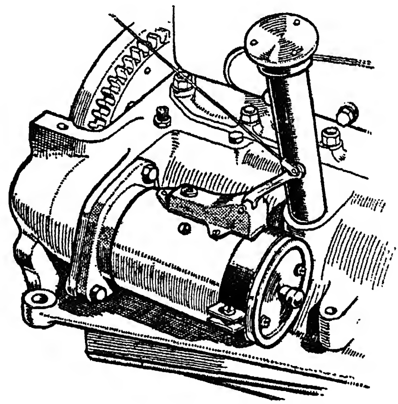
Consider a ratio of 3 to 1; this would be scarcely low enough for maximum starting torque, but it would mean that, with the engine running at 4,000 r.p.m., the dynamotor would rotate at 12,000 r.p.m. Suitable

compromises have been adopted by manufacturers so that the machines do not have to be geared too low as a starter or too high as a dynamo.

A refinement of the system consists in providing a variable-gear ratio by means of suitable sliding pinions. With the pinions in mesh the motor can be geared down as low as seven to one or even more, but when it works as a dynamo a direct coupling comes into action, so that the machine runs only at crankshaft speed. On some cars the dynamotor is directly coupled also as a motor. This is a perfectly satisfactory, but, naturally, somewhat expensive arrangement.

Starter Switch Gear.

Until recently the general method of operating the starter, whether of normal or dynamotor type, was by means of a push-button mounted either on the facia

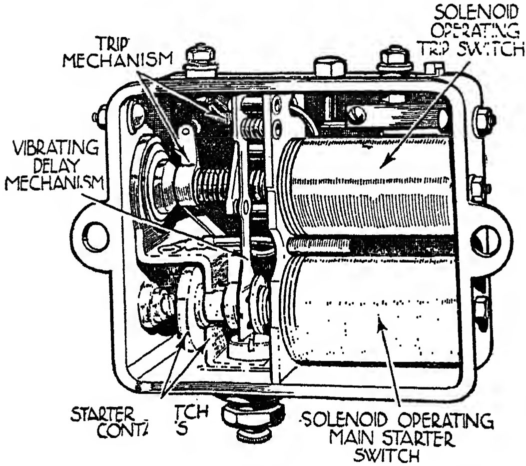


Example of a built-in starter switch operated by a wire and lever from the facia board.

board or on the floorboards. The heavy current passing makes it necessary for the switch contacts to be of very robust construction; also a cable from the battery has to be led to the switch, which, of course, is coupled by a further cable to the starter. The length

of the cables tends to give rise not only to a voltage drop in the circuit, but also to the risk of fire should the insulation become chafed and make contact with some adjacent metal part.

Electrical equipment manufacturers, therefore, turned their attention to other types of switch. In one arrangement the switch is mounted on the starter body and is solenoid operated, the magnetic circuit of the solenoid being completed through a small push-button on the facia board. This enables the cables to be shortened



Genera arrangement of the Startix automatic control mechanism.

considerably, as the push-button requires only two small wires carrying a current of, perhaps, two or three amps. Another scheme is to mount the switch on the starter body and to operate it mechanically by pulling on the wire attached to the facia board.

Startix Automatic Control.

Further steps to improve starter control were later introduced, and a very ingenious Lucas arrangement provides for automatic restarting whenever the engine

stalls. The facia-board switch has three positions for the key, "off," "auto" and "hand." Just above the switch is a small push-button. When the key is turned to the "auto" position the ignition is on and the automatic starter circuit is closed. In the "hand" position the ignition only is switched on and the starter is operated by pressing the small button.

The equipment consists of a sealed box which houses two solenoids, one of which operates the main starter switch whilst the other acts as a trip switch for cutting out the starter. From the accompanying illustration it will be seen that there is a single winding on the main solenoid A and two windings on the trip-switch solenoid B. The connections are arranged so that when the ignition is switched on, with the key turned to the "auto" position, current from the battery passes through the main solenoid winding and causes a plunger to be pulled in, closing the contacts C.

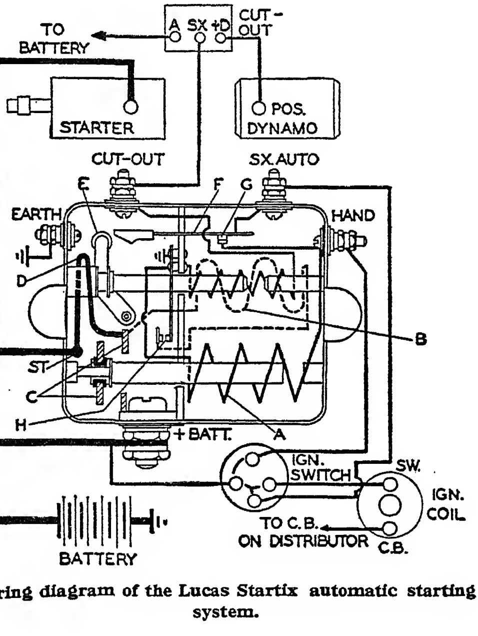
This operates the starter and at the same time allows current to pass to the outer of the two windings of the trip-switch solenoid. When the engine starts and the pinion is disengaged, the reduction in the current demand causes the trip-switch solenoid to be pulled in.

The lever marked E then moves the arm F, so separating the contacts G. This breaks the circuit in the main-switch solenoid and the plunger moves outwards breaking the starter circuit. When this happens the outer trip-switch winding is isolated, but the inner one is now energized by current from the dynamo, so that the plunger remains in the outward position. At full charging speed with the main cut-out contacts closed the "auto" contacts open and insert a resistance in the winding circuit, so that only a very small current flows.

If the engine stops the dynamo naturally ceases generating and the trip plunger is released. The main starter switch is not, however, closed immediately, because the movement of the trip plunger arm E flicks the spring-mounted contact arm F, the vibration of which prevents full contact being made at G, for exactly one second. This allows the engine to come to rest

before the starter pinion is re-engaged. A similar delay action contact H, in the outer winding circuit of the trip coil, prevents its immediate energizing. By this means time is allowed for the starter pinion to engage the flywheel ring before the trip mechanism opens the starting switch.

The "hand" position of the switch is used, of course, when automatic restarting is not desired. This may



Wiring diagram of the Lucas Startix automatic starting system.

occur when, owing to a run-down battery, the engine must be cranked by hand, or if a reading of an electrically operated petrol gauge is required without starting the engine.

The Lucas Startix system was formerly fitted to a number of makes of car.

CHAPTER IX.

Lighting Equipment.

THE importance of adequate and efficient car lighting cannot be over-emphasized; in fact, the whole subject of illumination on the road is covered by comprehensive legislation that includes the following regulations.

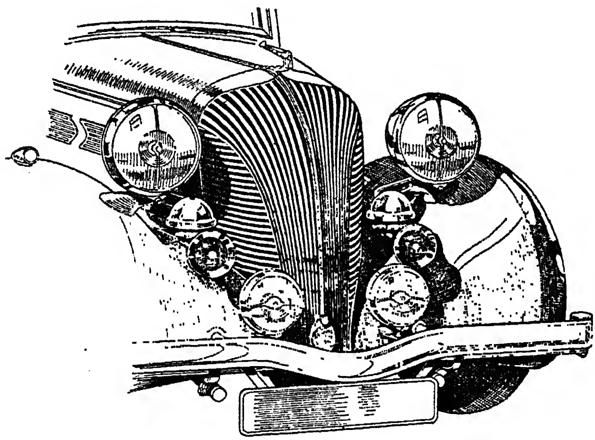
The law stipulates that two front lights must be carried by all two-track motor vehicles, including side-car combinations, and that such lamps must be alight during *Summer Time* between one hour after sunset and one hour before sunrise. For the remainder of the year the time extends between half an hour after sunset and half an hour before sunrise.

The two obligatory front lamps must indicate the full width of the vehicle; they must be kept in efficient condition and show a light visible from a reasonable distance. The power of these side lamps, however, is restricted to 7 watts for each bulb, and all bulbs must be clearly marked with their wattage. The beams from the side lamps must be diffused by frosted glass or other means.

A rear red light is compulsory for all motor vehicles, and because it is also obligatory to illuminate the rear number-plate a single lamp is generally employed to serve the double purpose. Two other lamps are usually carried at the rear of the car, namely, a red stoplight and a white reversing light. The stoplight is controlled by a switch operated by the brake pedal. Immediately the pedal is depressed the stop lamp lights up, both by day and after dark, giving instant warning of the intention to stop. On cars where the brake pedal and

hand brake are interconnected the stoplight switch is usually wired in series with the ignition switch. This arrangement allows the stoplight to be cut off when the engine is stopped; otherwise the lamp would remain alight whenever the car was parked with the hand brake on.

The reversing light is sometimes controlled by a switch operated from the gear lever when moved into reverse. A reversing light is very convenient when manœuvring a car in the dark and its automatic action is dispensed with during daylight by the use of a separate cut-out switch controlled by hand. It should

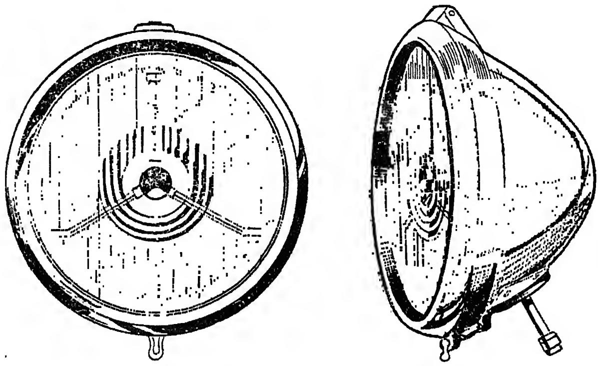


A typical lighting layout showing head, side and road lamps for use in fog or when passing other vehicles.

be understood that with the above exception no white lights are permissible at the rear of the car. Conversely, no vehicle may show a red light to the front.

Lighting regulations are also in force relative to parking and towing. Parked vehicles may be exempted from showing lights in certain specified parking places

under the direction of the police. Head lamps (as distinct from compulsory side lights) must be extinguished on stationary vehicles, but this regulation does not apply to vehicles during an enforced stoppage, e.g., through exigencies of traffic. A vehicle towing another vehicle need not show a red light, and a towed vehicle need not display a light showing to the front, unless the distance between vehicles exceeds 5 ft. A red tail light is essential, however, on a towed vehicle. With a statutory restriction on the power of side lamps it is obvious that special additional lamps are necessary



A powerful modern head lamp (Lucas) for high speed travelling at night.

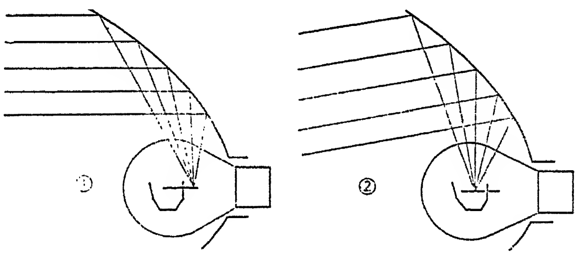
for safe driving along dark roads, and cars are accordingly fitted with two head lamps. These lamps, however, are subject to regulations and restrictions, the most important of which are anti-dazzle provisions. Head lamp beams must be either permanently deflected downwards or capable of such deflection or capable of deflection both downwards and to the left. Another variation permissible is that the beam shall be capable of being extinguished by a device which at the same time deflects the beam from another

lamp downwards (or both downwards and to the left) or operates another lamp permanently deflected downwards.

The regulations state that the effect of deflection must be that the beam of light is at all times incapable of dazzling a person standing more than 25 ft. from the lamp, and whose eye-level is not less than 3 ft. 6 ins. from the ground. Spot lights are permitted but must not be operated while the car is in motion.

Electric Lamp Bulbs.

The bulbs used in modern lighting systems are almost invariably of the gas-filled type. The term "gas-filled" means that instead of there being a vacuum within the bulb—as was the case in earlier times—it is filled



A double-filament lamp bulb showing (1) how the main filament light is reflected and (2) how the secondary out-of-focus filament gives a dipped beam.

with an inert gas, such as nitrogen or argon. By this scheme it is possible to raise the tungsten filament to a greater degree of incandescence; thus for a given current consumption a much more powerful light is produced.

In domestic lighting the term "half-watt" is often used to describe gas-filled bulbs; it is intended to imply that the bulbs give 2 candle-power per watt of current used. This is actually a rating which does not apply to lamps of under 300 watts.

Car-type lamp bulbs may use about 1 watt per candle-power, but only by a photometer test can the actual

candle-power be measured. It should be remembered, also, that, owing to the shape and positioning of the filament, the light emitted will be more powerful in one direction than in another. For this reason, where absolute accuracy is required, it is usual to give the mean spherical candle-power (M.S.C.P.), as plotted on a polar graph.

Whilst, when new, the efficiency of a bulb depends upon its design, the care expended upon its manufacture, and so on, there may be considerable losses when it is in use. Granting a fully charged battery, good wiring and clean connections, a bulb should give a very close approximation to its rated candle-power at its rated wattage.

Conditions can arise, however, which will cause a big drop in efficiency. Chief amongst these is the ageing of the bulb. After a considerable period of use the inner surface of the glass becomes blackened, due to emissions from the filament.

The darkening of the glass naturally cuts down the amount of light that can pass; thus, although the filament is taking its proper current and producing its rated candle-power, a large part of this is absorbed in passing through the black glass. It is false economy to continue using blackened bulbs; throw them away and fit new ones. The increased driving comfort will be well worth the cost.

One other point in connection with bulb efficiency. It is seldom worth while to buy very cheap bulbs. Some of them are good and will stand the most exacting candle-power and consumption tests; their effective life also is reasonable. Others, however, may be heavy in their current demands or badly made in that the glass is not properly cemented to the cap; the two may part company when the force necessary to engage the two pins with the bayonet joint is applied.

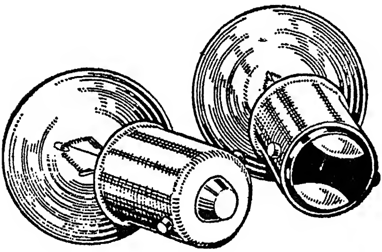
When dealing with unbranded bulbs, especially the head lamp type, one should beware of super-brilliance. It may seem very attractive to have additional candle-power for no increase in current consumption, but as

this result is achieved, as a rule, only by shortening the life of the bulb it is not so good.

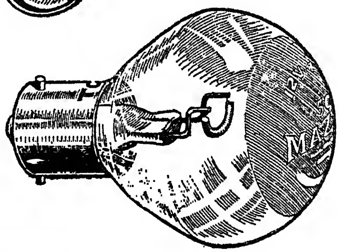
The scheme adopted is to over-run the filament—that is, to make it somewhat smaller than normal. This causes it to glow more brightly, but it will not last long; the extra voltage passing will burn it out.

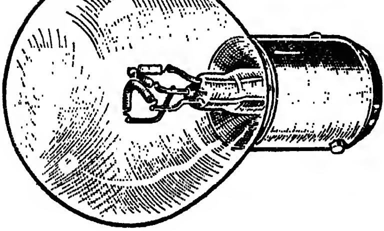
Single and Double Contact.

Car-lamp bulbs are usually of the small bayonet-cap (S.B.C.) type and single or double contact, according



Car lamp bulbs (left) of the bayonet catch single and double contact types.





Single filament Mazda bulb (above) and double filament type (left).

to whether the wiring system be single or double pole. In single-pole systems the current returns to the battery by way of the car frame. The lamp bulbs, therefore, have a single central contact in the base of the cap—

but insulated from it—to which one of the filament leads is soldered. The circuit is completed by securing the other filament lead to the metal of the cap. Assuming that the current enters by the central contact, it will pass through the filament and leave via the cap body, which is, of course, making contact with the metalwork of the lamp, and as this member is earthed an easy path for the current is provided.

In double-pole systems two insulated wires lead to each lamp and the bulbs have two contacts in their base, no current passing through the car frame.

Single-pole wiring is convenient and simple but it is important that all the earthed connections are perfectly clean. The formation of a film of rust, for instance, on a lamp mounting can easily set up so high a resistance to the current flow that the bulb will do no more than glow dimly or even refuse to light at all.

When such a fault exists the lamp must be unbolted and the contact faces scraped bright. Do not, however, paint them afterwards, as paint is an effective insulator. Further rusting can be prevented by applying paint, enamel or cellulose around the edges of the joint after it has been fully tightened.

Bulb-holder Faults.

The bulb holder in a lamp is provided with bayonet slots for engagement by the two pins which project from the bulb cap. Inside the holder are one or two spring-loaded plungers—one in the case of single-pole wiring and two with the double-pole system.

For explanatory purposes we will assume single-pole wiring and, therefore, a single plunger in the lamp holder. The wire leading from the switchboard is connected to the back of the plunger, which, of course, presses against the centre contact in the bulb cap.

Two points may be mentioned here; if the spring in the plunger should become weak, or if the plunger itself should stick, faulty contact will be made with the bulb, and the lamp either will not light at all or will flicker. This trouble is very rare, but it has

been known to occur. There is a possibility also of the plunger tip becoming corroded, so that an insulating film is formed between it and the bulb contact; this can well result in a lighting failure.

When fitting a new bulb difficulty is sometimes experienced in pushing it in far enough to engage the bayonet joint. The trouble is due, as a rule, to an excessive amount of solder having been applied on the centre contact, and the cure is to file away some of the solder.

Care must be taken to clean away all particles of solder from the surrounding insulation, otherwise a short-circuit may occur. This point is particularly important with double-contact bulbs, because there is, as a rule, only a small gap between the two contacts.

One other point in connection with bulb fitting: In some types of lamp there is a sleeve outside the bulb holder, and if the two pins which project from the cap are too long they will foul the sleeve and prevent the bulb from being inserted. Here, again, matters can be put right by the judicious use of a small file, with which the length of the pins can be reduced slightly. Do not, of course, clamp the bulb in a vice, as this would be sure to damage it; all the necessary filing can be done with the bulb held gently with the fingers of the left hand.

When dealing with the wires leading to the bulb holders it is important to see that there are no loose strands, which might set up a short-circuit by touching an adjacent earthed part. As a rule, in the case of double-contact bulb holders, there is a small piece of insulating material between the two terminals. If this be missing a piece of cardboard or a short length of insulating tape, folded over, can be inserted.

Care of Reflectors.

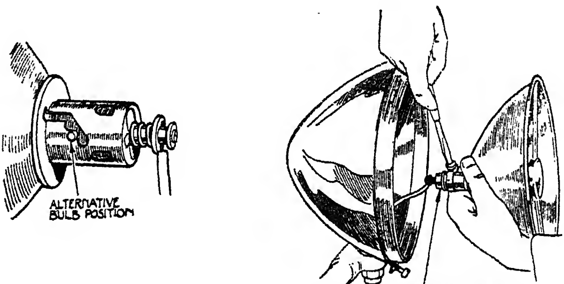
Lamp reflectors usually are of parabolic shape and formed from thin sheet metal. The reflecting surface is silver-plated and highly polished. To preserve the lustre it is usual for manufacturers to cover the surface with a special form of varnish.

For this reason no attempt should ever be made to clean reflectors with metal polish, but it is permissible occasionally to wipe them with a piece of very soft material, such as a silk handkerchief. If the silvered surface has no varnish coating and shows distinct signs of tarnishing it may be cleaned with jewellers' rouge, but nothing more abrasive than this should ever be used.

A dull reflector will absorb a considerable amount of light, therefore if maximum efficiency is desired one should have no hesitation in sending the reflector away for replating; this is a comparatively inexpensive job. The reflectors are, of course, protected by the glass fronts of the lamps, and if a glass be cracked or broken no time should be lost in obtaining a new one, because otherwise the reflector will very quickly tarnish.

Focusing Arrangements.

Head lamps are almost invariably provided with some form of focusing device, so that the projected light may be used to the best advantage and according to



Lamp bulbs are focused by the use of a three-notched bayonet catch (left) or a sliding holder that can be adjusted with a screwdriver (right).

individual requirements. In some cases the bulb holder is provided with three bayonet slots, in steps, as it were, so that three positions of the bulb relative to the reflector are obtainable. In other designs the lamp

holder is slidably mounted in the reflector and clamped by means of a screw at the back.

There is another arrangement in which the adjustment is made by turning a screw situated in the rear of the lamp body. This scheme is rather to be preferred, as focusing then becomes a very simple operation, which can be carried out without first removing the front of the lamp.

The stepped bayonet holder has certain advantages, and where standardized bulbs are used one of the three positions available may be relied upon to provide the desired focusing. To make an alteration it is necessary only to remove the lamp front, but it must be borne in mind that if the job be done whilst the lamp is alight the bulb will be extremely hot, and should therefore be held with a cloth.

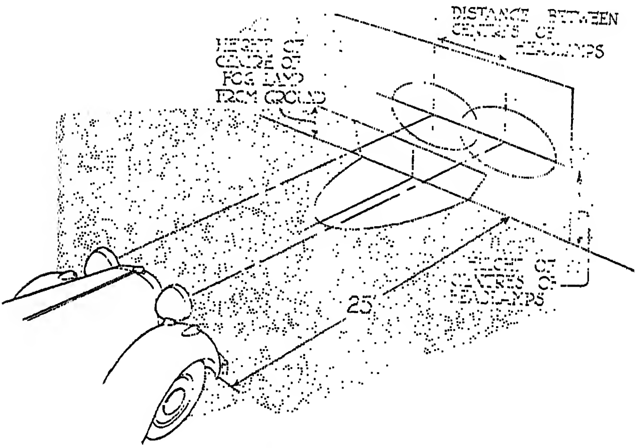
Where the focusing is carried out by means of a sliding bulb holder it is necessary to remove the reflector from the lamp body before access can be gained to the clamping screw. As a rule the reflector is held in place by three spring-loaded tongues which fit into slots formed at its front edge. If one of these be first disengaged by pressing it down the reflector can then be released easily from the other two. There will be a sufficient length of wire within the lamp body to enable the reflector to be drawn far enough forward to get at the screw.

It is a good plan when about to focus a lamp of this kind to slack the clamping screw just enough to allow the holder to be pushed in or pulled out fairly easily, but it should not be loose. The reflector can then be replaced and the holder moved as necessary by grasping the bulb.

It is now necessary to say something regarding the actual focusing operation. An approximate setting can be arrived at by driving the car to a point about 25 ft. from a flat vertical screen, such as a garage door, a wall or a fence. Switch on the head lamps and note the position of the discs of light thrown on to the screen. These should be quite clearly defined.

How to Focus Head Lamps.

If the two discs are not at the same height they must be made so by altering slightly the angle of the lamps. This is done by slackening the clamp nuts of their mountings and moving them as necessary. The centres of the two discs of light should be the same distance apart as the actual centres of the lamps. This measurement can easily be made with a long rule or with a piece of string stretched taut. The height of the



Method of focusing head lamps and a pass lamp.

discs of light should be slightly less than the actual height of the lamps from the ground.

When this setting has been made the two lamps can be focused by movement of the bulb holders until both discs projected on the wall are of the same diameter. This may be all that is required to provide a good driving light, but, in general, it will be found much more satisfactory to regard the preparations just described merely as a preliminary to more accurate setting, which must be carried out on the road.

The Final Setting.

Drive the car—at night, of course—to a suitable stretch of straight road where there are no lamp-posts or other sources of light. If the road has a kerb or a row of trees along it so much the better. Drive in a perfectly normal manner and note the projection of the light-beams ahead. If they are not quite satisfactory stop the car, mask one lamp by throwing a coat over its front and adjust to angle or focus of the exposed lamp as required. Treat the other lamp in the same manner and try again.

Some little patience and a considerable amount of adjusting may be necessary before ideal conditions are arrived at, but take care, after each alteration, to get back into the driving seat in order to judge the result, as a quite erroneous opinion is liable to be formed if the beams are viewed when standing more or less level with the front of the car. Finally remove the reflectors to lock their clamping screws, secure the lamp fronts and tighten the mounting nuts.

Actually the last-named job should be done first, because if the lamp fronts are difficult to replace there is the possibility that in pushing them on the lamp body will be shifted, unless it has first been tightened.

Where the near-side lamp is provided with a dipping reflector it is advisable before assuming the adjustments to be correct to test this lamp in the dipped position, because it may happen that, although the straight-ahead projection is satisfactory, the dipped beam does not come quite where it is desired. In that case one must, as it were, split the difference, bearing in mind that it is very advisable to have efficient illumination when the beam is dipped.

Head Lamp Glasses.

In most cases special forms of glass are used in head lamps with the object of producing a diffused light around the main beam. Sometimes the glass is merely stippled, but on the more expensive lamps it may be domed or convex and moulded into a series

of vertical convex lenses; in addition, there may be a special centre formation composed of a series of prisms, from which the wide-angle beam is refracted.

It will be clear from this that in the event of a lamp glass being broken an ordinary piece of glass will not be a satisfactory substitute, although there is every reason for fitting it temporarily in order to protect the reflector whilst the proper lens is being obtained. Any glazier will cut the necessary disc of plain glass for a few pence.

Dipping and Switching Systems.

Let us turn now to a consideration of the dipping and switching mechanism usually incorporated in head

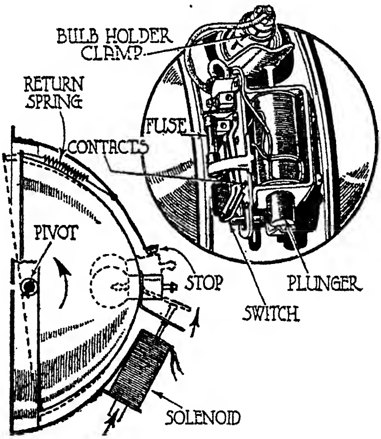


Diagram of the Lucas dipping device operated by a solenoid.

lamps. In the latest examples the control is almost invariably electrically operated, but there are many cars still on the road in which the near-side reflector is dipped by pneumatic means, and there are systems which actually tilt both lamps on their mountings by mechanical control—that is, by rods and levers or with a Bowden wire.

With electrically operated dipping control the mechanism is carried within the body of the near-side lamp. It takes the form of a solenoid, the plunger of which pushes a bracket on the underside of the bulb holder, thus tilting the reflector to the dipped position. Upon reaching the end of its travel the plunger opens a pair of contacts, thereby bringing into circuit a high-resistance winding, which limits the amount of current flowing to a fraction of an ampere. When the current is switched off the reflector is returned to its normal position by means of a spring.

The dipping mechanism gives very little trouble in practice, but should it show sluggishness in operation or should the off-side head lamp fail to cut in or out when the control switch is moved an examination of the dipping mechanism will be necessary.

It can be exposed by removing the lamp front and taking out the reflector in the manner described earlier in this chapter. The solenoid and its contacts will be found mounted on the reflector frame, and it will be noticed that there is a small cartridge fuse placed across the windings, and that there is a spare fuse mounted in clips nearby. Make sure that the working fuse is held firmly in its clips. The various contacts can be examined for signs of burning or corrosion and cleaned as necessary. In general, however, any fault developing in the dipping mechanism should be entrusted to a service station for correction.

Pneumatic Switching.

On the pneumatically operated dipping systems a small air cylinder is mounted on the reflector frame; it is provided with a piston the connecting rod of which is attached to the reflector. Incorporated with the dipping device is a switch by means of which the off-side lamp is extinguished when the reflector is dipped.

The air cylinder is connected by rubber or metal tubing to another cylinder mounted on the steering column or some similar point, readily accessible to the driver. The cylinder contains a plunger which when

pulled upwards creates a vacuum in the pipe line and the reflector air cylinder. This causes the piston to move up the cylinder, thus dipping the reflector.

The troubles which can arise with this system centre mainly in air leakage past the plungers or through faulty tubing. Each plunger is provided with a leather cup washer and should these become dry they will allow air to escape. From time to time, therefore, a few drops of thin oil should be fed into the plunger cylinders. The operating plunger has a small screw in its side, and if this be taken out the oil can be introduced through the hole exposed, after which the screw is replaced.

The cylinder on the reflector has a small air-escape hole in its side, and oil can be applied through this; at the same time not more than one drop should be allowed to fall on the plunger spindle, but take care not to overdo the oiling, as surplus lubricant may find its way on to the switch contacts and cause faulty operation. Perished rubber tubing should, of course, be replaced by new lengths where necessary.

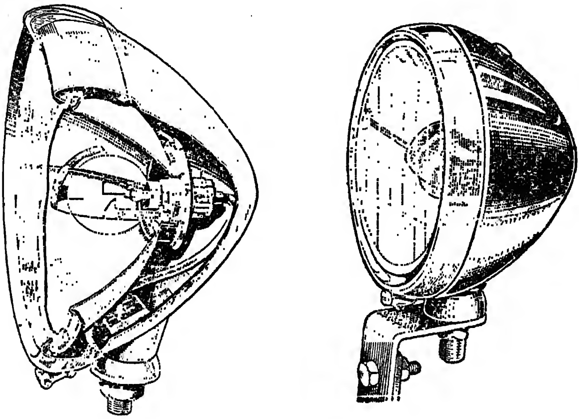
On some cars a dipped effect is achieved by the use of double-filament bulbs, one filament being set out of focus. Movement of the dipping switch cuts out the main filament and cuts in the auxiliary, which, by reason of its position relative to the focal point of the reflector, causes the dipped beams to be projected. This scheme has the great merit of simplicity and is clearly shown in the illustration appearing on page 105 in this chapter.

Driving in Fog.

Before leaving the subject of lamps some consideration must be given to the question of fog driving. It can be shown by scientific means that a white light is a drawback in fog, as it sets up back glare, which is very confusing to the driver. Certain forms of yellow light, however, do not possess this drawback, but it must be understood that it is not so much a question

of the colour of the light as its optical properties that have to be considered.

Light is of varying wavelength, starting with ultra-short waves at one end of the spectrum and ending with much longer waves, comparatively speaking, at the other. Fog is composed of an infinite number of tiny particles of water. They are so small, in fact, that they form a definite barrier to the passage of all



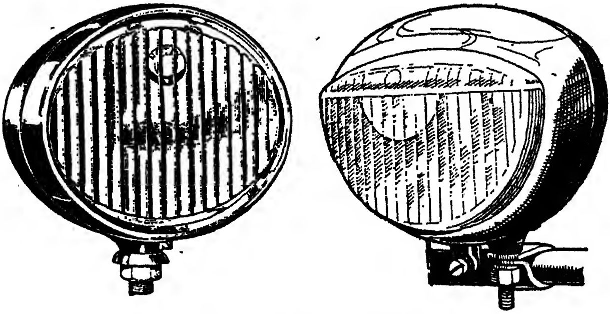
For driving in fog. The Lucas auxiliary lamp, in section (left) and the Smith fog and road lamp, with hooded bulb (right).

light of short wavelength, which is thus reflected back by the particles.

Long-wave light, however, can pass them; therefore if one can filter out the short-wave light without affecting the long waves, a very useful illuminant for driving in fog can be obtained. This has been done commercially by means of a special form of glass known as Nebulite, which stops all light of wavelength greater than green in the spectrum, but allows the yellow part to pass with undimished power; thus, by using Nebulite glasses in the head lamps or in a special fog lamp a considerable help in fog driving is obtained.

There is also a special cadmium-yellow bulb available,

which produces similar results, but failing these special arrangements, satisfactory progress can usually be made in fog by covering the lamp glass with thin yellow paper. The head lamps should be dipped, and it may be worth while to tilt them considerably on their mount-



The Notek fog and pass light (left) and the Raydyot Meteor driving lamp (right).

ings, so that the beams are projected downwards close to the front of the car. A much better scheme, however, is to have some approved form of fog light carried low down on the near-side dumbiron and directed towards the kerb.

CHAPTER X.

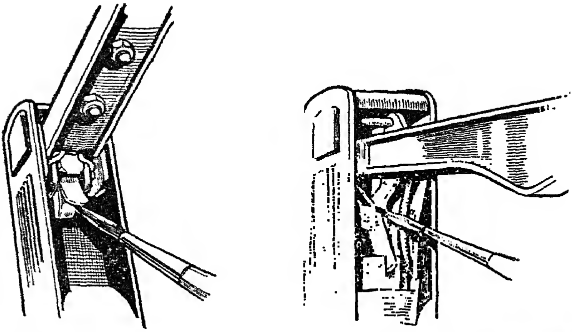
Traffic Indicators.

ONE of the most useful auxiliaries fitted to the modern car is the direction indicator.

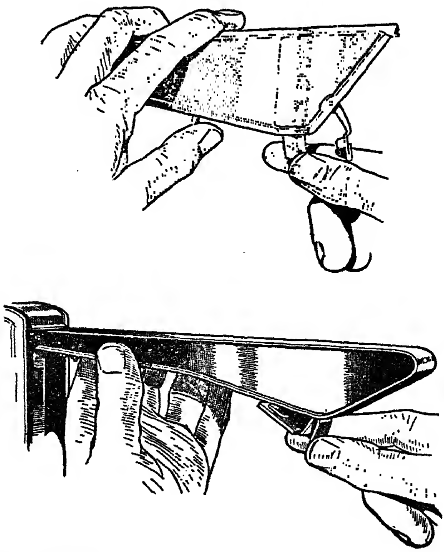
Operated by a switch from inside the car, these indicators, because of their convenience, are used far more frequently than were hand signals in pre-indicator days. In many ways the indicators are better than hand signals in that they show up more distinctly both during the day and at night. Indicators, especially at night time, give the driver added confidence in the knowledge that any other road user close at hand should be aware of any intention to turn or pull out. The convenience of the indicator is really appreciated to the full when the weather is cold and wet, and one would not feel so inclined to wind down the window and give a hand signal. In view of their utility a little attention to the car's indicators is well worth while.

Occasionally the operation of the indicators should be watched to see if they are working efficiently. The arms should come out without any hesitation, and the bulbs should light up immediately the indicator is horizontal. Arms should drop right back into their casing as soon as released. On some cars little round mirrors are fitted at the top corners of the screen, and these should be adjusted so that, when either arm is out, the driver can see its reflection.

The semaphore arms are usually solenoid operated, and contacts are arranged so that the internal lamps are switched on as soon as the arms attain a horizontal position. The energizing of the solenoid causes the core to move inwards, so pulling up the arm to which it is



Thin machine oil, applied on a brush, will ensure smooth working of the joints and sliding contacts in traffic signals.



Methods of gaining access to the bulbs in two types of Lucas Trafficator.

connected. Movement of the contacts can be watched by closing the operating switch so that the arm is lifted and then switching off with the arm held in the horizontal position. The arm can also be moved up and down to disclose any places where there may be a tendency to stick . The arm should not be pulled from its casing, as this procedure may damage the mechanism. If the arm rises but does not light up, the bulb may have burnt out, and it should, of course, be replaced as soon as possible.

Removing the Bulbs.

The method of changing a bulb varies with different makes of indicator, but it is in all cases quite simple. Although the arm must be lifted by operating the switch, the bulb must not be removed while it is switched on, as it is possible to cause a short circuit in doing so. After the arm has been lifted by using the switch it should be held up and the switch returned to its off position. The bulb holder can then be withdrawn. The bulbs are not all secured in the same way. Some indicators are provided with a metal tongue, which clips the bulb holder to the underside of the arm. On some flush-fitting types access to the bulb is obtained after releasing the cover, which is secured by a small trigger beneath the arm. Another type of indicator has a metal plate secured to the underside of the arm by a screw; removal of screw and plate gives access to the bulb.

Most direction indicators are wired on the earth-return system, and the earth contact must be really good. Failure of one or both of the signals can often be traced to a bad earth connection.

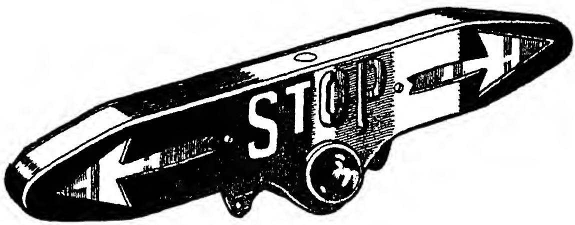
Indicators are usually wired through a fuse, which may be in the auxiliary circuit or in a separate indicator circuit. This fuse must, of course, be inspected in the event of a failure as it may have blown. In that event the circuit should be closely inspected to discover any reason for the breakdown. A loose wire or a short circuit might easily be the cause and would, of course,

have to be rectified before fitting a new fuse. Otherwise the fuse would obviously blow again.

Lubrication.

The hinges of traffic indicators should occasionally be lubricated very sparingly with thin machine oil, so that the arms work perfectly freely. This may be done with a feather or small paint brush.

The arms are not pulled down but drop by their own weight, and being made very light they will not return to their casings properly if slightly bent or if the hinges are stiff. Obstruction inside the casings, such as disarranged cables, will also prevent their proper action.



A traffic indicator with arrows illuminated by switch control. The "stop" signal is illuminated by depression of the brake pedal.

Fixed Indicators.

Another type of indicator used on some cars consists of fixed signals in the form of illuminated arrows displayed from a casing secured to the car in a permanent position. These indicators are sometimes attached to both the front and rear of the car, and either pair of arrows—left hand or right hand—can be illuminated by operating a switch from the driver's seat.

Stoplights.

An indicator which is now fitted to the majority of cars is the stoplight. This takes the form of a red light usually larger than a normal tail light. Sometimes a triangle or the letters STOP are used over the lamp,

which is illuminated as soon as the brake pedal is depressed, giving due warning to following cars that the brakes are being applied. This is a particularly useful signal at night time, when it is more difficult than in daylight to see the change in speed of the car in front. The foot brake makes the necessary connection with the lamp switch as soon as the pedal has travelled a certain distance. On cars fitted with hydraulic brakes the stoplight is sometimes operated by a switch worked by the master cylinder.

Testing Earth Connection.

Nearly all stoplights are wired on the earth-return system, and in case of a failure the earth connection should always be inspected after duly testing the lamp bulbs for broken filaments.

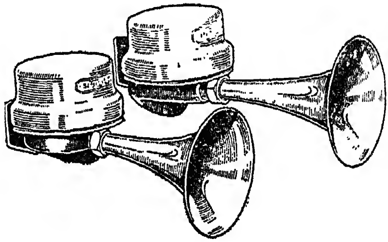
The following is a good method of testing for a faulty earth connection. With the lamp switched on, by depression of the brake pedal attach one end of a wire to some good earth connection or, if possible, to the earthed terminal of the battery. Then touch the side of the bulb cap with the other end of the wire. If it lights it shows that the earth connection is not making proper contact. Any other lamps which do not appear to be of their usual brilliance can be tested in a similar way with a length of flex to a nearby earthed point. Occasionally a car is seen fitted with a lamp at the back which, when illuminated, reads THANK YOU; this is operated by a push button on the dashboard—usually after passing a car which has given way to the overtaker.

CHAPTER XI.

Electrical Auxiliaries.

ALTHOUGH the lamps, ignition and starter equipment may be termed the essentials, uses of electricity extend to a somewhat extended list for car auxiliaries. To name a few, we have electric horns, windscreen wipers, direction indicators, de-frosters, air-conditioners, engine and radiator heaters, fuel pumps and gauges, clocks, and even cigarette lighters, with radio in addition. Some of the above are essential, all are very convenient.

Among the essentials it would probably be correct to



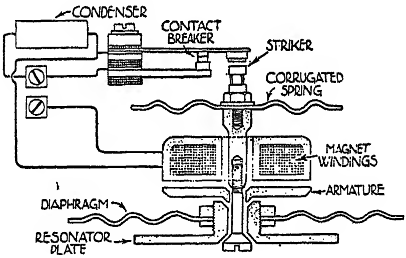
Twin horns, by Chalk and Harris, that give a clear and pleasant toned warning note.

include electric horns and windscreen wipers; the former may be required at any moment, the latter will certainly be needed all the time it is raining. It must be borne in mind, however, that no kind of warning signal may be sounded in a "built-up" area between the hours of 11.30 p.m. and 7 a.m. Because of this regulation many motorists give silent warning by flashing a spotlight, or the head lights, on the road ahead. For this purpose the operating switch may take the form of a

horn-type push-button. Alternatively, a change-over switch in the horn circuit can be used, so that the horn button will flash the head lamps.

High-frequency Horns.

Most car horns now in use are of the high-frequency type, giving a penetrating but musical note. The principle on which the high-frequency horn works is similar to that of the simple vibrating type, in which an electro-magnet attracts an armature secured to a circular sheet-metal diaphragm, held rigidly around its circumference. A contact breaker, operated by the movement of the armature, causes the diaphragm to vibrate when the control button is pressed and the



Details of a typical high-frequency electric horn (the Alto). A study of the diagram will show the operating principle.

sound is amplified by a suitable horn or trumpet. The modern high-frequency horn incorporates a number of improvements on the simple vibrator and is, therefore, capable of producing a very loud note with a satisfactory tone. The high-frequency horn is fitted with a powerful electro-magnet and generally the armature is laminated to render it suitable for high-speed working. A condenser is shunted across the points of the contact breaker to prevent excessive sparking.

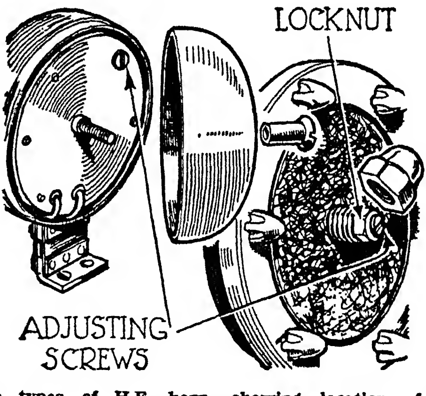
The alloy-steel diaphragm is either flat or corrugated and in some designs is stiffened by flat springs. The most important addition to the diaphragm is the resonator plate. This comprises a disc of some light

metal, such as magnesium alloy, and it is attached at its centre to the outer face of the diaphragm. The disc is thus free to vibrate and, because of its low weight, it has little inertia. The resonator plate, therefore, builds up a frequency far in excess of that of the diaphragm, so giving the required high-pitched note.

Most high-frequency horns have an adjustment for the contact breaker, for diaphragm movement or for both. It is not advisable, however, to attempt more than adjustment of the contact breaker; diaphragm setting requires expert attention. Most electrical service stations have special facilities for horn tuning.

Adjusting H.F. Horns.

In some horns the adjusting screw is behind the resonator plate or in the centre of the plate spindle.



Two types of H.F. horn, showing location of the adjusting screws.

The resonator can be removed by unscrewing the centre nut and the adjusting screw is then rotated about a quarter of a turn. The horn button should be pressed and the result noted. A true idea of the alteration in the sound cannot, of course, be gained until the resonator plate is replaced, but the test will show whether the note has been raised or lowered. At the same time,

the ammeter will show the amount of current that the horn is taking. An incorrect adjustment may result in excessive current consumption, although the note may be satisfactory from the musical point of view. In this event it may be necessary to sacrifice tone in favour of economy.

Motor-driven Horns.

Another type of warning device that has been given satisfactory service is the motor-driven horn. In this instrument an electric motor drives a ratchet wheel, the teeth of which strike a "pip" attached to the diaphragm. There is generally a short lever at the back of the motor casing and this is moved slightly in a clockwise direction, so pushing the ratchet closer to the pip and thus altering the note. The ratchet wheel should not be set too close as this will result in an unpleasant groaning sound; also the motor will be overloaded. The setting should allow the motor to speed up rapidly to its maximum with the pitch of the note rising correspondingly.

A type of horn that gives a powerful, yet pleasant, note is operated by compressed air. The compression pump is driven by a small electric motor, both components being contained in a compact cylindrical unit. Twin horns, containing air-operated reeds, are mounted independently or together on the power unit. Independently mounted horns are supplied with compressed air from the unit by flexible tubing.

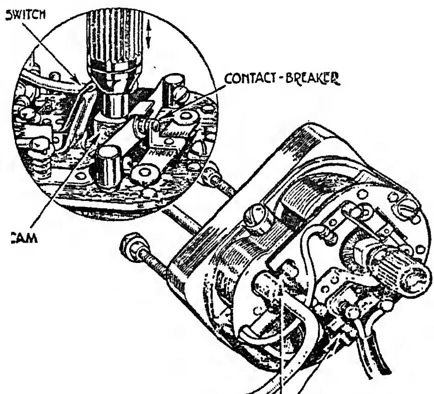
Fitting a New Horn.

When fitting a new electric horn, it is important that the wires used be of ample section. The voltage drop caused by undersized cables may result in a poor note. It should also be remembered that, if an earth return be used, the horn bracket must be free of paint or other insulating material on its contact surface. High-frequency horns must be mounted on very rigid supports, as anything flimsy will vibrate badly when the horn is working and so spoil the note. Another matter that must not be overlooked is the condition of

the spring and contacts in the horn button. The spring that maintains the button in the "off" position must be kept in good condition, otherwise the contacts may stay in the working position with embarrassing consequences. A certain amount of sparking at the contacts is unavoidable and the metal surfaces may require attention occasionally with a fine file or glasspaper to clean up the pitted or oxidized surfaces.

Electric Screen Wipers.

The screen wiper is an important auxiliary on a car and, nowadays, it is nearly always electrically operated. There are several kinds in general use, but they differ

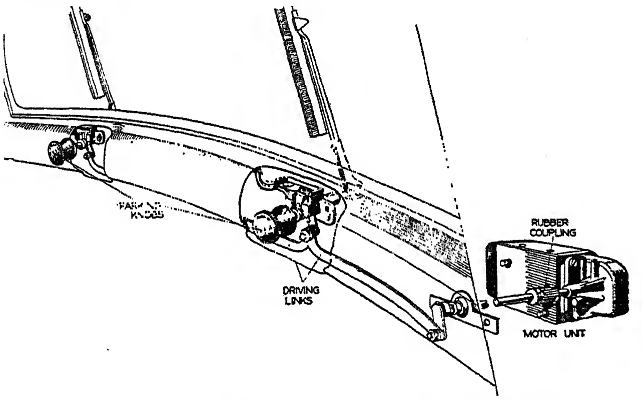


The Lucas spin-type electric screen wiper, showing the points of adjustment and other details.

only in certain points of design with regard to the motor and the wiper-arm gearing. The older Lucas type, of which there are still very many in use, has an "attraction" motor in which there is a winding only on the field magnet—the armature being a plain, laminated assembly with four equally spaced poles and shaped rather like a ratchet. It rotates between the field poles as in an ordinary type of motor, but instead of a commutator the armature spindle carries a small, four-lobe

cam, which operates a contact breaker connected in series with a field winding.

A motor of this kind is not self-starting, and when used for a screen wiper is provided with a small milled knob, which also performs the function of a switch. The action of pulling out the knob closes the circuit. The knob is then spun between the fingers and causes the armature to rotate; in doing so it operates the contact breaker, so that the field winding is intermittently energized, thus the armature is alternatively pulled round and released. Its inertia carries it over the non-magnetic intervals, so that rotation is continuous.



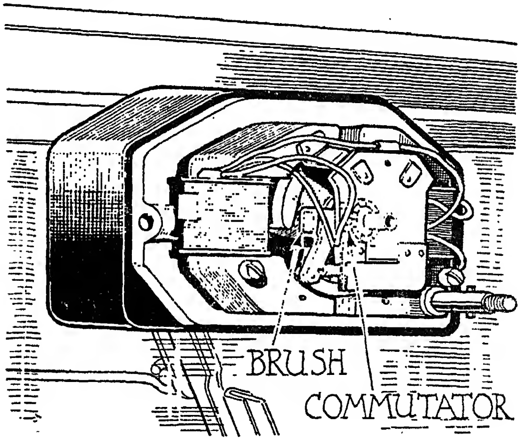
A motor-driven screen wiper fitted with twin blades.

Adjustment and Maintenance.

This type of motor has the merit of great simplicity and it is fully reliable. Occasionally the contact points require attention, just as do those of an ignition contact breaker. The gap is adjustable and its setting is somewhat important, as upon it depends, to a large extent, speed of the motor. One of the points is carried on an insulated plate held by two screws to the main assembly. The screw holes are slotted, so that if the screws be slacked back a little the plate, together with the contact, can be moved, and by this means the gap is altered.

As the armature spindle runs at a comparatively high speed it is necessary to provide reduction gearing, so that the wiper blade will not move too fast across the windscreen. It will be clear, also, that the rotary motion of the gearing must be converted to semi-rotary motion on the wiper spindle. This is done by the use of a simple form of connecting rod, which is enclosed with the gearing at the back of the motor assembly.

The gearing is accessible for lubrication or examination by removal of the back plate, and good-quality



A Lucas self-starting screen wiper motor.

grease or petroleum jelly may be used as the lubricant; a large quantity is not required, as it will tend to set up too much drag. With this type of screen wiper the armature spindle runs in a long bearing, and this may, with advantage, be lubricated with graphited oil as, in some cases, grease will not find its way along the full length of the bearing.

Self-starting Wipers.

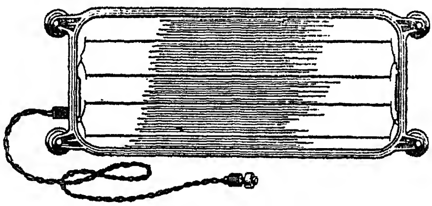
Where the screen wiper has a self-starting motor this is of the usual wound-armature type with a commutator and brushes. The operating switch may be either

attached directly to the motor casing, or remote control may be used. The motors are designed to run for long periods without attention, but occasionally the cover should be removed for inspection and cleaning of the commutator and brush gear. The lubrication attention necessary is similar to that mentioned in connection with "spin-start" wipers.

In those types of screen wiper having tandem blades, a dash-mounted motor and concealed operating gear, the rack or chain motion will require occasional lubrication.

De-frosters.

The modern windscreen wiper is quite an efficient device that can be relied upon to function under all normal conditions. Driving during the winter months,



A de-froster (Berkshire) with rubber suction cups for attachment to the windscreen.

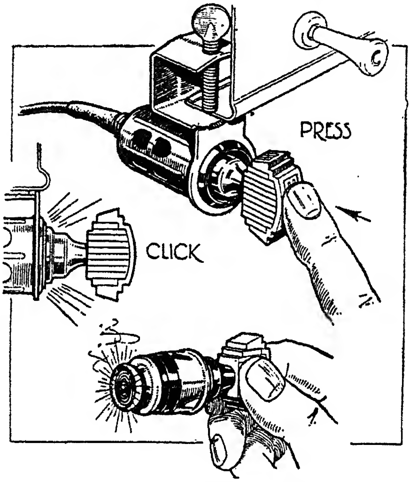
however, conditions may prove too much for the windscreen wiper. Snow, frozen mist, sleet and ice must be contended with on the outside of the windscreen, whilst inside the car the glass is misted over by condensation. Both of these difficulties can be overcome by the modern de-froster.

This device consists of a resistance-wire heating element, which is connected to the battery circuit. In some de-frosters the heating element is contained in a strip of ebonite or similar material, which is attached to the inside of the windscreen by suction cups. Other de-frosters comprise a glass panel in place of the element strip, and these fittings are provided with a rubber-edged frame, which is drawn against the windscreen by

the suction cups and thumb nuts. This type of de-froster keeps the windscreen warm and, at the same time, warms its own panel, so overcoming the misting caused by condensation.

Cigarette Lighters.

A less important, but very convenient, use of the battery for heating purposes is demonstrated by the numerous lighters now on the market for smokers. In one popular type of cigarette lighter a plunger is inserted



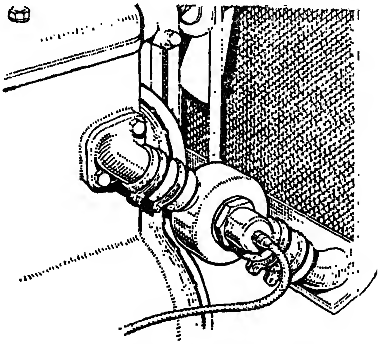
A useful type of electric cigarette lighter, the operation of which is explained in the text.

into a socket, where it is held by spring clips; the heating circuit is then automatically completed. The lighter is held by the clips until the heating element attains a predetermined temperature. A thermostatic control then releases the spring with an audible "click," which is the signal to remove the lighter and apply it to the cigarette.

Mains Heaters.

We now come to a type of heater that works off the house mains and is a valuable safeguard against freezing

of the water in radiator or cylinder block. Mains heaters are hung inside the bonnet or placed on the garage floor beneath the engine. In one well-known heater—the Bray—the whole unit fits into the lower waterpipe from the radiator. It is, in effect, an immer-

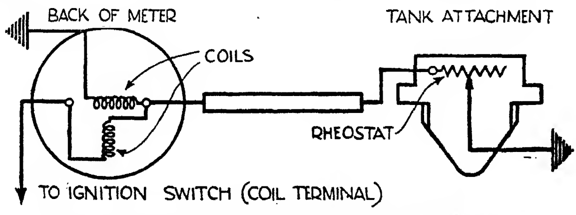


An electric heater, permanently fitted, which keeps the water well above freezing and assists in making a quick start on a cold morning. It is the Bray and draws current from the house circuit.

sion heater similar to those used for domestic purposes, and not only does it prevent trouble from frost, but it also ensures a rapid initial start of the engine. A lead from the heater is plugged into the garage mains, which supply current throughout the night.

Electric Petrol Gauges.

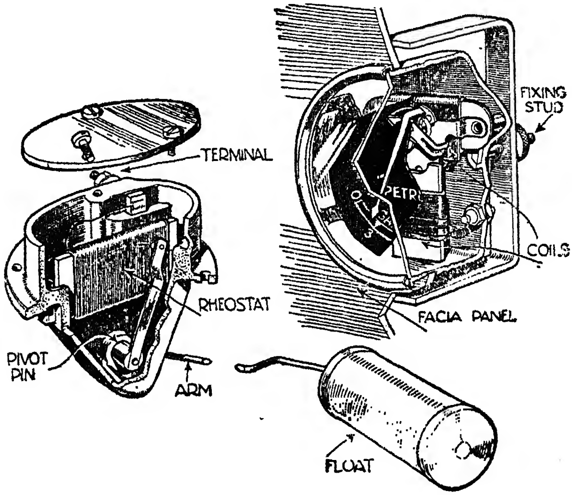
Another important electrical accessory is the petrol gauge. It requires no maintenance attention and does



Wiring diagram of the Smith electric petrol gauge.

not, as a rule, give trouble. In a standard type of gauge there are two units, the dial and the float assembly; they are connected by a wire and the circuit is completed via the ignition switch, an earth return being used.

The needle of the dial gauge carries an armature swinging between two coils and moving towards one or the other, according to the magnetic "pull" exerted.



Details of the Smith electric petrol gauge. The tank component which carries the float is shown at the left, with the panel instrument top right.

This pull is controlled by the tank unit, which consists of a float attached to the end of an arm. The other end of the arm, through the medium of gearing, actuates the contact brush of a rheostat, or variable resistance.

It will be clear, therefore, that as the level of the fuel in the tank varies the float, in rising or falling, will cause the brush to move across the rheostat, thus altering the amount of resistance in the circuit and so varying the magnetic pull of the two dial coils.

The presence of electrical mechanism practically

inside the petrol tank gives rise to no risk of fire, as the unit is sealed in a corrosion-proof casing and the float spindle passes through a gas-tight bush. Provided that the dial gauge is accurately calibrated, a true reading of the tank contents will be given, as the instrument is not affected by variations in battery voltage. Current consumption, by the way, is very low—between .16 and .10 amp.

Although neither the dash unit nor the tank unit is liable to give trouble, external wiring faults may develop which will put the gauge out of action.

For instance, if the needle does not move when the ignition is switched on, it is probable that the wire between the gauge and the switch is disconnected. If the gauge shows "full" under all conditions, look for a fault in the wire between the dash unit and the tank unit.

Earthing faults are indicated by the needle always pointing to "empty." If an examination fails to disclose the fault it is possibly in one of the two units, and a replacement may be necessary. This is a job for the service station.

Electric Fuel Pumps.

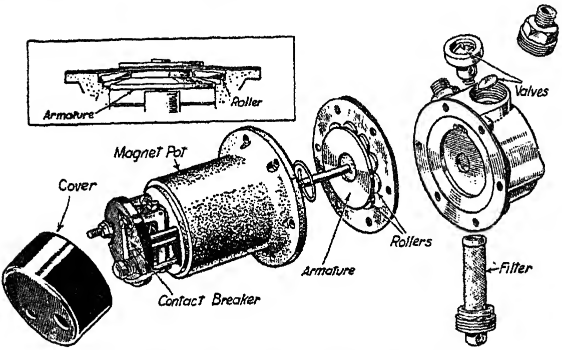
Electric fuel pumps are in very regular use on modern cars; the later types feed the fuel under pressure to the carburetter, but in the earlier models gravity feed was adopted. In both instances the S.U. pumps are very popular. The pressure type consists of three main parts, the body, the magnet assembly and the contact breaker.

Inlet and outlet valves, together with a filter, are contained in the base of the pump. A wound cast-iron magnet, carried within the body, is close to an armature, which is located by 11 spherical-edged brass rollers; these ensure correct positioning and absolute freedom of movement.

The contact breaker consists of two rockers, the inner of which has screwed to it a bronze rod connected to the armature. The outer rocker carries a tungsten

point, which makes contact with a further point secured to a spring blade. One end of the magnet coil is connected to the blade, whilst the other end is connected to a screw terminal.

The circuit is completed to earth via a short flexible wire connected between the outer rocker and one of the screws in the moulding of the contact-breaker housing. Where double-pole wiring is used, the wire is led from the rocker to an additional screw terminal.



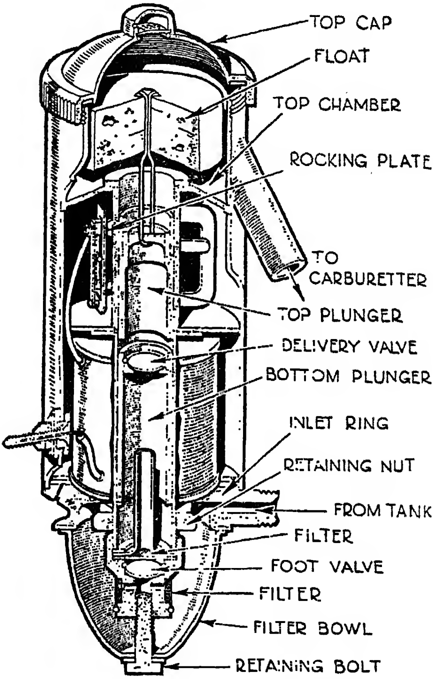
An S.U. pressure-type pump dismantled to show the general construction. (Inset) How the armature is supported on spherical rollers.

When the pump is at rest the contacts are closed. So soon as the current flows the magnet is energized and attracts the armature. This deflects the pump diaphragm, causing petrol to be drawn into the pump chamber. Towards the end of its "stroke" the armature trips the contacts, which, in opening, break the circuit, so that the armature and diaphragm return when contact is again made, and the cycle of operations is repeated.

Electrical troubles are unlikely to develop and little maintenance attention is needed as the width of the contact-breaker gap is of no importance.

Should the pump refuse to work when current is switched on, disconnect the lead from the terminal and

strike the end against the body of the pump. If current is available sparks will appear. The moulded cover of the pump is then removed for examination of the contact breaker. If the points are closed and a spark cannot be struck off the terminal it is probable that the points are dirty. Conversely, open contacts indicate that the armature has not gone right back.



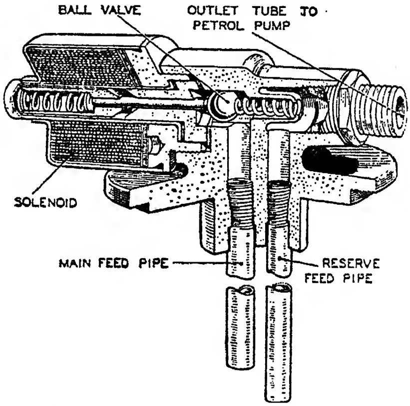
This sectional view of an S.U. Petrolift pump shows clearly the arrangement of the various parts. The float controls the movement of the pump.

This trouble may be overcome, as a rule, by slacking the six screws which hold the magnet housing to the body and making sure that the diaphragm is not sticking to the magnet housing; alternatively, it may be dirt

that is causing the sticking, in which case it will be necessary to dismantle the main magnet assembly.

A noisy pump indicates an air leak on the suction side, whilst steady working without petrol being delivered is usually a sign that dirt has lodged under one of the valves. If the pump becomes very hot and seems to have difficulty in working, look for an obstruction in the delivery pipe.

The gravity-type S.U. pump is of very simple construction. An electro-magnet, energized by the car



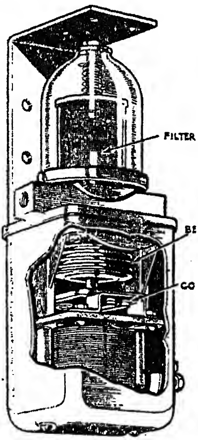
An electrically operated reserve petrol tap. Normally both pipes are in use, but when the level falls the solenoid closes the main pipe, leaving the reserve in action.

battery in the ordinary way, attracts and releases, through the medium of a contact breaker, a plunger connected to the pumping element. As the plunger approaches the top of its stroke it moves an iron sleeve upwards, and this short-circuits the magnetic flux existing at the upper poles of the magnet system.

The weakening of the upper magnetic field has the effect of strengthening that at the lower poles, which then attract an iron armature operating the contacts. When these open the magnetic circuit is broken, the pump plunger falls and the cycle is repeated.

The pump is not liable to electrical failure, but occasionally the contact breaker should be exposed for examination of the points. Grit in the pumping element may cause sluggish working or complete failure, whilst it is important to see that there are no air leaks on the suction side of the unit.

In the Autopulse fuel pump a coil having a hollow core attracts an armature, which carries two pairs of tungsten contacts; a helical spring, located in the hollow core, returns the contacts to the "open" position.



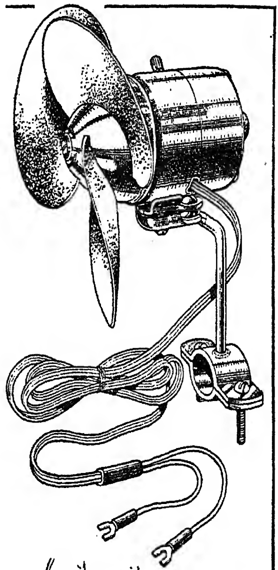
The Autopulse fuel pump which is fitted to some cars has metallic bellows operated by an electro-magnet.

Projecting upwards from the armature is a small screw which engages with the pumping unit.

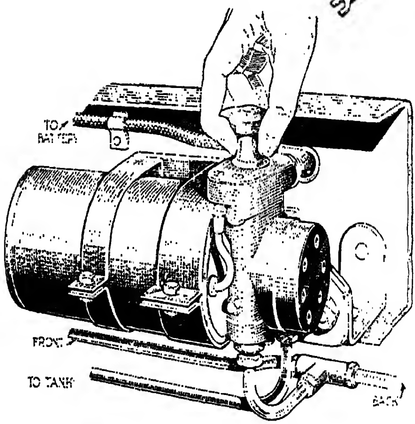
This consists of a metallic bellows, expanded and contracted by movement of the armature and working, of course, in conjunction with the usual inlet and outlet valves. A domed-glass filter unit surmounts the complete assembly.

The Autopulse pump works normally on the earth-return wiring principle and is unlikely to give trouble in use. The dual contacts very seldom require attention, but the pump is not difficult to dismantle when necessary.

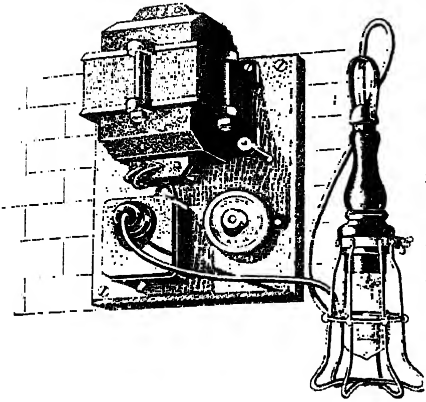
ELECTRICAL ACCESSORIES FOR THE CAR



The Casco electric fan for cooling the interior of a car in hot weather. The fan blades are made of sheet rubber.

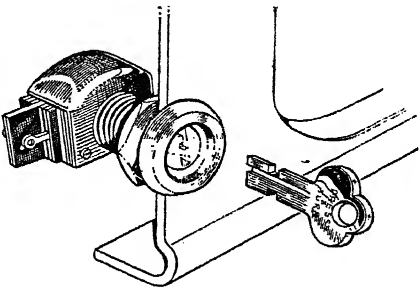


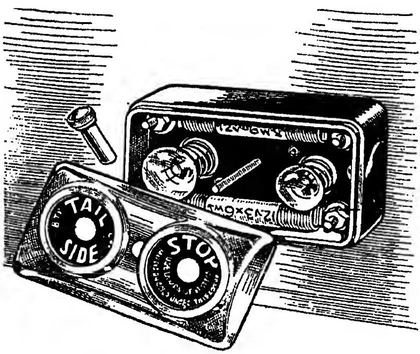
Wheel jacking is facilitated by the improved Power Jackall unit which comprises an electric motor-driven pump and control operating a set of hydraulic jacks.



An inspection lamp that operates at 12 volts from a transformer mounted on the garage wall. This type of lamp is, of course, safer than those that are plugged direct into the mains.

This Bulgin switch serves as an anti-theft device. It is wired in series with the ignition system and is readily attached to the facia board.



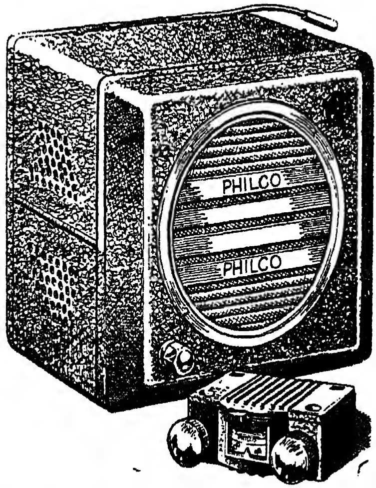


A useful tell-tale unit. The lamps are wired in series with the lights indicated, so that any failure is shown immediately.

CHAPTER XII.

Car Radio.

WHEN first introduced, car radio aroused a certain amount of controversy, but it is now generally conceded that the innovation should be encouraged, and some cars even carry a built-in wireless set as standard equipment. The fitting of radio sets in cars is becoming increasingly popular and receivers have now attained a high degree of performance. There are, of

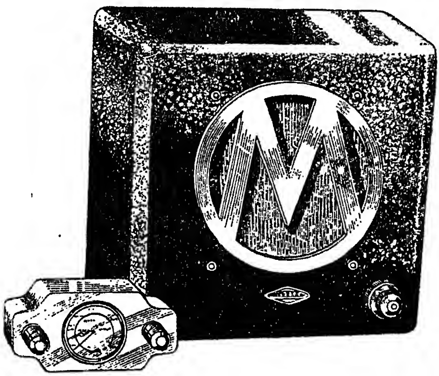


The Philco radio receiver-speaker with remote control tuning.

course, certain points that must be watched to obtain the best results. For example, owing to the possible sources of electrical disturbances on a car special precautions must be taken to prevent interference. Similarly the question of vibration has to be considered.

From the point of view of signal range and quality of reception, the design and position of the aerial are important factors.

It is usual with car radio to take the current from the car battery, the low-tension supply being tapped off direct. The high-tension current supply is a little more difficult, as it is necessary to step up the voltage. This may be done by a vibrator-converter, or a small motor generator may be fitted. A more simple method is to obtain the high-tension current from a separate dry battery, which will need replacement from time to time. In the most popular car radio installa-



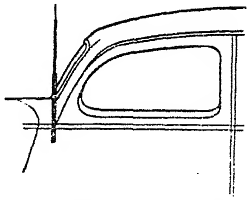
The Masteradio set and tuning control unit on which the names of transmitting stations are indicated.

tions both high- and low-tension supplies are taken from the car battery, the drain on which varies from 2.5 amp. to 5 amp. (from 12 volts).

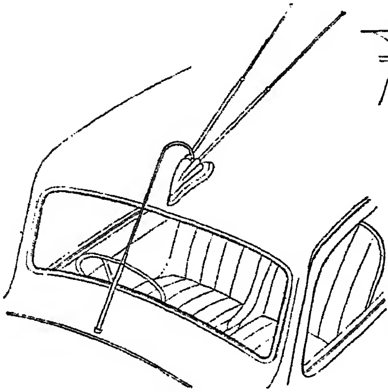
The Aerial.

If the roof of the car be of fabric or wood, a sheet of wire gauze may be used to form an efficient aerial; it would, of course, be concealed. When the car has a metal roof then the aerial must be fitted underneath the car. Hitherto, such a type of aerial has taken the form of either a number of insulated copper rods

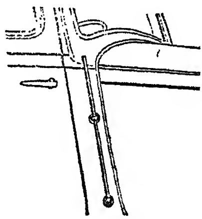
CAR RADIO AERIALS



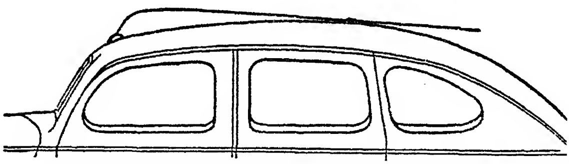
Philips aerial fitted to door hinge.



The V-type roof aerial with lead-in through scuttle.



A telescopic aerial on side of scuttle.

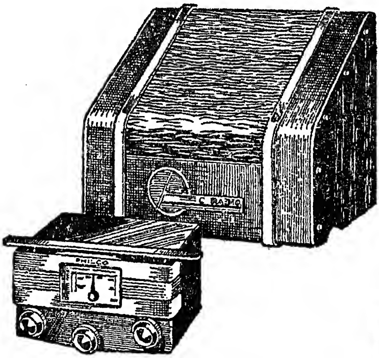


Overhead aerial (Philips) attached at two points to the roof of the car.

The Avenet aerial, which is mounted beneath the running board.

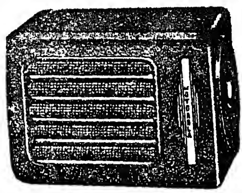
or sheets of wire gauze held between rubber or fibre clamps slung under the running-boards. It may be mentioned that many specially built bodies afford no support for an aerial of this type.

An ingenious aerial constructed on a new principle has been introduced recently by the makers of Philips radio equipment. The aerial itself is suspended by means of rubber tubing, the tubing being clamped to



A Philco radio set (above) with receiver and controls in one unit and amplifier with speaker in the other.

The Motorola radio set (below) which is supplied with a separate push button control unit.



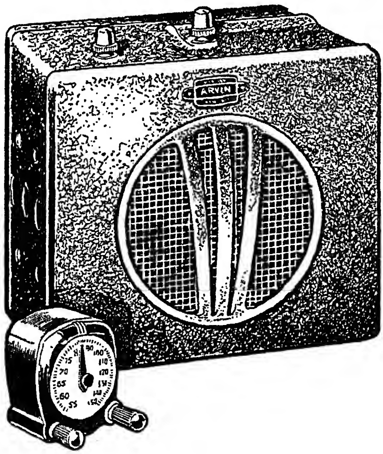
the chassis frame. If the aerial, which consists of copper rod in the form of a "V," strikes an object, this flexible mounting prevents risk of damage. Such an aerial has a certain wavelength which eliminates part of the interference from the electrical installation. The closer the aerial of this type is fitted to the ground the greater its efficiency. There should be no reason why an amateur could not install it quite easily.

Other types of aerial now extensively used are shown in the accompanying illustrations; these are not unsightly and may even enhance the appearance of some streamlined cars.

Housing the Set.

The actual housing of the set is sometimes a problem, as if it be located in the rear locker some form of remote control with its attendant lengths of cable become essential. This system has not proved entirely satisfactory, especially in cases where the work has been carried out by someone lacking the specialized knowledge which car radio installation demands.

Generally speaking, the more direct the control the more satisfactory are the results obtained, and from this point of view those sets which are constructed for direct mounting behind the facia board have much in their favour as the operation then becomes precisely the same as a normal set.



The Arvin radio receiver with separate control unit.

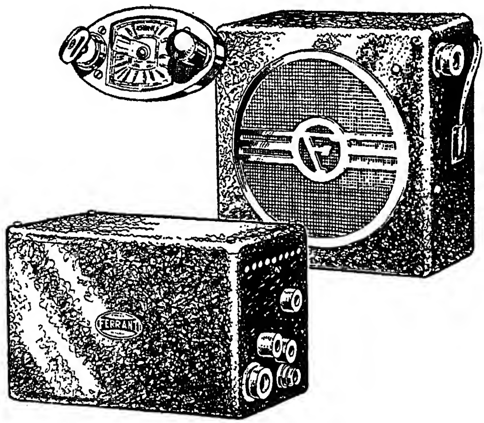
Separate or Built-in Loudspeakers.

As to whether the loudspeaker is built into the set or forms a separate unit is purely a matter of taste or convenience in installing. With a separate instrument one has a choice of position in which to erect it;

probably the best location is either in the roof or in one corner of a saloon, but here again this is purely a personal matter. In the case of the built-in speaker its location, of course, depends upon where it is found most convenient to install the set.

Low Current Consumption.

The actual output required from the set is not large, because as the speaker is enclosed in a small space quite moderate volume suffices in all normal circumstances. Nevertheless, the available capacity of the battery demands attention, as in certain makes of car of the

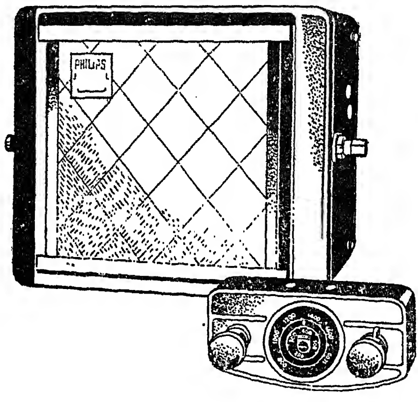


The Ferranti radio set, comprising panel control, loud speaker and separate receiving unit.

popular type there is but little reserve, especially during the winter months when the car lighting system is being used continuously. This fact has led car radio manufacturers to concentrate on the production of installations which will run with a current consumption less than that of one average head-light bulb. There are, of course, 6-volt and 12-volt radio sets.

Suppressing Interference.

The most important problem which manufacturers of car radio have had to solve is that of suppressing extraneous noises, such as are emitted by the dynamo, ignition system, and other items of electrical equipment of a car. Such interference suppressors may be of an external type or built into the set itself. In some cases the interference caused by the sparks discharged across the sparking plugs is suppressed by means of a resistance in the high-tension leads, but as this sometimes means adjusting the plug points closer it cannot be considered entirely satisfactory. It would seem, therefore, that a



Philips Motoradio with built-in speaker and separate control unit.

better system is that in which such interference is by-passed in the set itself.

The majority of modern sets do, in fact, have the necessary interference suppressors incorporated in their design. It is sometimes desirable to fit also a condenser across the dynamo terminals and a suppressor in the distributor H.T. lead. The dynamo brush gear and commutator must be kept in good condition, as a badly sparking commutator can cause interference in spite of

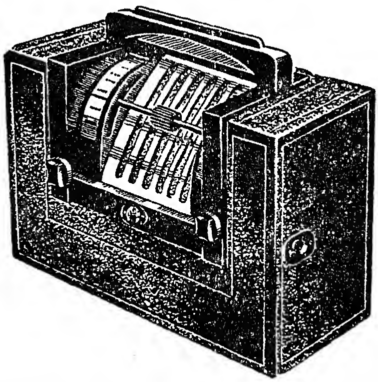
suppressors. Similarly if the contact breaker and plug gaps are not kept correctly adjusted trouble will be experienced from these sources.

Any increase in the distributor gap caused by the burning of the rotor tip or electrodes may also cause interference.

Controls.

The modern car radio set is usually under the control of the driver, as apart from being sometimes the only occupant of the car, there are certain conditions when it may be desirable temporarily to switch off the loudspeaker.

Car radio sets are usually provided with an on-off



The McMichael Bijou portable receiver with Rotabar tuning.

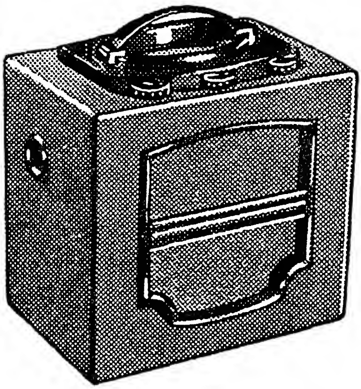
and volume control switch, a tuning control, a wave change switch, and sometimes a variable tone control in addition.

The tuning dial, which may be illuminated, is sometimes marked with the names of stations.

The panel containing the main controls is usually a separate unit so that it can be mounted on or beneath the facia board or on the steering column. These are

remote controls and a removable key or knob is provided for the on-off switch to prevent unauthorized use of the set when the car is parked or garaged.

During the day perhaps only five or six stations may be picked up, but after nightfall conditions are always better and stations can be received "all round the dial." On some receivers the variable tone control and wave change switch are mounted on the set itself,



A portable radio set that can be carried in the car for picnic and seaside use. (Philips.)

because to provide remote controls for these would increase the cost of the set without giving compensating advantages.

Push Button Tuning.

The latest addition to car radio is push button tuning with a six-button remote control panel. By pushing one button at a time the set is automatically tuned to that station; any six stations can be selected by the purchaser on installation. A small electric motor operates the tuning condenser when the buttons are pressed, the receiver being isolated while the motor is working to avoid interference. The button must remain depressed until the motor has stopped when, on

releasing, the set will be correctly tuned to the selected station.

Another system by which it is possible to tune without taking the eyes from the road is "spot tuning," which usually allows eight stations to be selected.

The set is tuned from the remote control panel in the usual way, and the positions of the selected stations are indicated by the "feel" of the tuning knob. This is effected by a small steel ball that catches in an indentation in a brass worm wheel along which it travels. The ball is squeezed into the brass worm in the eight positions during assembly thus defining the positions of the stations permanently.

Portable Car Radio.

An interesting form of car radio which differs from car radio proper is the portable battery type. It cannot be compared with the specially designed built-in radio, as it has a very different and in some ways wider appeal. The portable is also considerably cheaper, costing £6 to £10 as against the built-in type that costs from 12 to about 20 guineas.

Portable sets may be used in a moving car to receive local stations of good strength which can usually be heard above the click, click, click of the ignition. Their main use, however, is when the car is stationary, as far better reception is then obtained. They are particularly useful when caravanning, picnicking or at the seaside or country bungalow, all of which occasions have a necessary connection with motoring.

A four-valve set can pick up dozens of stations on the medium and long wave lengths during the day, and at night time many more stations can be received. Reproduction is good, but owing to the different working conditions it is, of course, not quite up to the standard of an expensive household set. A portable set casing measures about 11 ins. by 9 ins. by 6 ins., and contains a 100-volt H.T. battery and a 2-volt 80 ampere-hr. accumulator of the unspillable jelly type, in addition to the valves, other components, speaker and aerial.

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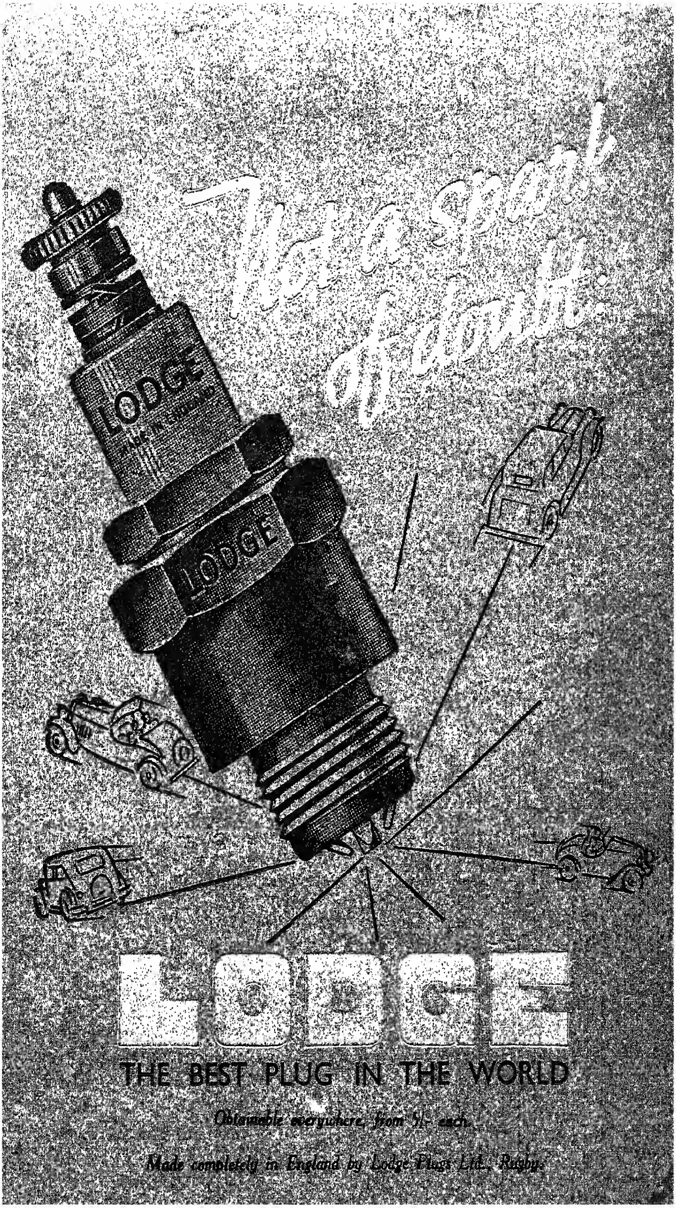
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